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The AWA Review

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Cover Images: The world's first home video Teleplayer manufactured by Motorola beginning in 1968 appears on the front cover of this issue. This electronic video recording (EVR) system, which once led the industry by ten years, was a playback-only system that could not record signals in the home. On the back cover is a photograph of the Teleplayer with the cover removed. Both pictures are taken from "CBS Electronic Video Recording (EVR) and the World's First Video Teleplayer" by Olin Shuler.

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Foreword

We are fortunate again this year to have eight high-quality articles with a diversity of topics covering more than a century of electronic communications history. We welcome as a new author to the *AWA Review*, Donna Halper, Associate Professor of Communication and Media Studies at Lesley University, Cambridge, Massachusetts. We look forward to receiving manuscripts from more new authors in the future. A brief summary of each article follows in the order they appear.

- **David and Julia Bart** recount how the Russian wired telegraphy system evolved from its early beginnings with Russia's first optical telegraphy line that was installed in St. Petersburg in 1824. They explain that wired telegraphy in Russia began with the Crimean War, which started in October of 1853. With great skill, they take us through the many developments in telegraphy since the Crimean War. They conclude by pointing out that it was the Crimean War that spurred the growth of Russian telegraphy in the 19th century, and then explain how that helped to lay the seeds for future revolution and the ultimate collapse of Imperial Russia in the early 20th century.
- **Donna Halper** preserves the story of Greater Boston's pioneering broadcast stations 1XE and WGI, which were owned and operated by American Radio and Research Corporation, also known as AMRAD. She says that the stations were home to many of Greater Boston's best-loved entertainers and announcers. Donna also says that this station is all but forgotten today, and explains why it deserves to be remembered. Indeed, Donna has done an admirable job in documenting the major events in the life of these two stations.
- **Mike Molnar** uncovered a lost link in the chain between broadcast radio and television by finding a complete kit in near mint condition for a "Cooley Rayfoto System of Radio Pictures for the Home." Mike uses this kit as a springboard to tell us fascinating stories about systems of facsimile transmission made by other radio pioneers using the technique known at the time as "phototelegraphy." These systems were similar in purpose to today's facsimile machines, but the machines he describes used the radio for transmitting images rather than telephone lines.
- **John Okolowicz** says that advertising agencies experimented with methods to make the best use of expensive magazine ad space for promoting radio and TV products in the golden age of radio, and in doing so, many creative techniques were used to grab the reader's attention and get potential consumers to buy their products. John identifies twenty different techniques, and provides

examples for each, all in color, that were employed to create visually appealing radio, phonograph, and television ads from the early 1920s through the 1970s.

- **Olin Shuler** says that he acted as the scribe for five engineers, including himself, who worked at Motorola in the 1960s to develop and manufacture the world's first Teleplayer for the CBS Electronic Video Recording (EVR) system, which was designed for playback only through the television set for use in homes, schools, and industry. Olin documents their recollections from the time CBS awarded Motorola the contract in December of 1968 to design and manufacture the Teleplayer to the time the entire EVR program was cancelled by CBS in December of 1971.
- **Robert Rydzewski** returns this year to regale us once again with the adventures of Zen Bouck in Part 2 of "Zen Bouck, Radio Adventurer," as Bouck goes to Central America on a good will tour visiting several neighboring countries to the south. If you will recall, Rydzewski recounted Bouck's radio exploits in Bermuda last year. Rydzewski has outdone himself this year in researching the details of Bouck's exploits south of the border by contacting a myriad of sources, including a radio aficionado in Brazil with knowledge of Zen Bouck's exploits there.
- **Eric Wenaas** investigates the claims made by and on behalf of Mahlon Loomis that he communicated by aerial telegraphic signals to a distance of 20 miles in the Blue Ridge Mountains of Virginia in 1866, thirty years before Marconi's successful experiments in England. Eric determined that the Loomis antenna could have transmitted electromagnetic waves, but that it would have been impossible for Loomis to detect these waves using a galvanometer, and also it would have been impossible for him to communicate intelligence to any distance with electromagnetic waves using energy extracted from the earth's electrical environment.
- **Dan Brown** reviews the history of signal processing used by the Voice of America from the time it began broadcasting high-frequency (HF), amplitude-modulated (AM) programs during World War II to the present day. Dan conveniently divides his paper into analog and digital signal processing techniques, and claims to have uncovered some details that have been buried for decades and not brought to light until now.

We extend our sincere thanks to the authors for their excellent articles and to the reviewers for their able assistance in reviewing the articles and making suggestions that improved the manuscripts. I also thank the two associate editors,

Bill Burns and Joe Knight, who assisted me again this year. Their contributions were considerable. The *AWA Review* used the services of book designer Fiona Raven once again to prepare the *AWA Review*. Her help this year was invaluable, as it has been in the past. We thank Fiona once again for her contributions and creative spirit.

The word-searchable cumulative Table of Contents has been updated this year and is now current though Vol. 31. This index can be accessed on the AWA website at <http://www.antiquewireless.org/awa-review.html>.

I have enjoyed serving as the editor of *AWA Review* this year and working closely with each and every author. I look forward to receiving manuscripts for your articles next year. Tips for authors who intend to submit articles follow.

Eric Wenaas, Ph.D.
Editor
San Diego, California

Tips for Authors

The *AWA Review* invites previously unpublished papers on electronic communication history and associated artifacts with a focus on antique wireless. Papers will be peer reviewed to verify factual content by reviewers whose identity will remain anonymous. This process gives the *AWA Review* credibility as a source of correct historical information. The papers will be edited to provide uniformity in style and layout among the articles. In general, shorter articles of six to eight pages (3,000 to 4,000 words) or less should be directed toward the *AWA Journal*, which is published quarterly. The *AWA Review* is intended for longer articles on the order of 6,000–8,000 words. Longer articles may be accepted with pre-approval by the editor.

The *AWA Review* will also publish Letters to the Editor as deemed appropriate. The letters should comment on articles published in the previous issue of the *AWA Review* or make brief comments on wireless history as it relates to one of the articles. Letters will not be peer reviewed, but they may be edited. Text is limited to 400 words and no more than 10 references. The editor reserves the right to publish responses to letters.

It is strongly recommended that authors planning to prepare an article for the *AWA Review* send an abstract of approximately 200 words to the editor describing the subject and scope of the paper before writing the article, including an estimate of the number of words. It is never too early to submit an abstract. Space in the *AWA Review* is not unlimited, so it is important for both editors and authors alike to have an estimate of the expected number of articles and number of pages for

each article as soon as possible. The deadline for submissions of manuscripts in 2019 is January 1. Papers will be accepted after January 1, but papers submitted and accepted for publication before January 1 will have priority in the event that there is not space for all papers submitted.

Authors with an interesting story to tell should not be discouraged by a lack of writing experience or lack of knowledge about writing styles. The *AWA Review* will accept manuscripts in any clearly prepared writing style. Editors will help inexperienced authors with paper organization, writing style, reference citations and improving image quality. Edited manuscripts will be returned to the author along with comments from the editor and anonymous reviewers for the author's review and comment. The manuscript will then be set in its final form and sent back for one final review by the author. Normally, only one review of the layout will be accommodated.

To summarize, please submit completed manuscripts by January 1, 2019 (or earlier if possible) in three separate files:

- 1) A manuscript file *without* embedded figures or figure captions using Microsoft Word or other software that is compatible with Word. The manuscript should have a 200-word abstract, a main body with endnote citations and endnotes, acknowledgements, and several paragraphs summarizing the author's background.
- 2) A figure file with numbered figures that match the figure callouts that *must* appear in a sentence of the manuscript text.
- 3) A figure caption file with a short description of each figure and an attribution for each figure identifying its source.

You may use the articles in this issue as a template for the style and format of your paper. For more information, consult the AWA website at <http://www.antiquewireless.org/awa-review-submissions.html>. Please feel free to contact me for any questions.

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The Russian Imperial Telegraph

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The Crimean War set the stage for modern warfare. Many innovations were tested, including the first use of telegraphy in warfare. At the outset in 1854, the telegraph was not even twenty years old. Needle instruments dated from the early 1830s, and Samuel Morse's demonstrations took place in 1844. Yet, telegraph networks were expanding across Europe and across the Eastern United States by the early 1850s. Numerous writings document the British and French experiences in the war. This article reveals the development of the Russian Imperial Telegraph and its impact on Russia.

Introduction: The Crimean War

The Crimean War laid the seeds of modern warfare. A deteriorating Ottoman Empire offered Imperial Russia the strategic opportunity to exert control over the Black Sea, the Eastern Mediterranean, and the Middle East. By the early 1850s, Roman Catholic interests, supported by French, Eastern Orthodox Christian, and Russian interests, made competing claims for minority religious protections within the Ottoman Empire. Access to important transportation routes toward British India and the Holy Land also presented major issues affecting the balance of power. Hostilities began in July 1853 when Russia occupied the Danubian Principalities, an Ottoman dominion located in modern day Romania. Efforts to negotiate an international resolution failed, and war was declared in October 1853. For 28 months in 1854 and 1855, the Allies (British, French, Ottoman Turks, and Sardinians) fought primarily on the Crimean Peninsula against Russia. The Austrian Empire and the

Prussian States remained neutral. Many generals on both sides had not fought in a major battle since Waterloo, forty years earlier. Bravery on both sides was squandered by incompetent leadership, hardships from Russian winter conditions, shortages of food and supplies, poor medical treatment, and the impact of new technology.¹

The Allies landed at Eupatoria in September 1854 and marched toward Sevastopol, the capital of the Crimea and the location of Russia's naval base on the Black Sea. The 35-mile trek involved legendary battles such as Alma, Balaklava, Inkerman, Tchernaya, Redan, and finally, the Siege of Sevastopol in September 1855. New technologies such as rifled artillery, railroads, naval armament, military nursing and field hospitals, and the first use of wartime telegraphy were all tried. British war correspondent William Howard Russell and others memorialized the experiences of soldiers in the war (see Fig. 1). Following the fall of Sevastopol, Russia and the Allies signed



Fig. 1. Charge of the Light Brigade, an 1895 oil painting by Richard Caton Woodville, Jr., is an iconic representation of the battle. (Wikicommons)

the Treaty of Paris agreeing to end the conflict in March 1856, but only after 750 thousand were killed or wounded, approximately two-thirds of them Russian. Total Russian deaths in the war are estimated at one million military and civilian personnel.

Communications to the front were limited. Between 1853 and 1855, the German firm Siemens & Halske constructed the Russian Imperial Telegraph system, providing a vital link from St. Petersburg through Moscow south to Sevastopol. The telegraph also went west to Warsaw and to the Austrian border. With a total length of 10,000 km (6,214 miles), it was the longest single line in Europe. In contrast, British Royal Engineers established telegraph lines from British Headquarters at Balaclava to French Headquarters in Kamiesch, a distance of 21 miles. A separate underwater cable connected Balaclava

to Varna in Bulgaria. The French then constructed telegraph lines reaching the Austrian frontier and the continental network. Operation was tenuous and only marginally useful; yet, the Allies were able to connect their capitals with their generals.²

Five years after the war, examples from Crimea prompted General George B. McLellan, President Lincoln, and the Union Army to fully embrace many of these new technologies in the American Civil War. And one of the most important contributors to the Union victory was its expansive use of the electric telegraph, first tried in the Crimea.³

European Electric Telegraphs by 1854

European and American development of the electric telegraph generally paralleled the growth of railroads, and many of the first experimental electric telegraph

lines ran along railroad rights of way. English inventor William Fothergill Cooke (1806–1879) and English scientist Charles Wheatstone (1802–1875) began experimental work in the early 1830s. They installed their first telegraph line along the London and Birmingham railway in 1837 and their first French telegraph line in 1842 along the Paris and Versailles railway. Austria introduced the Bain telegraph in 1846 and extended its lines to Prague by 1847 and Budapest by 1850. Wheatstone demonstrated his telegraph in Germany in 1843,⁴ and by 1849 the Siemens & Halske telegraph system was in public use between Berlin and Cologne in Prussia. Most European networks began utilizing American Morse instruments as their common system after the 1852 formation of the German Austrian Telegraph Union.⁵ The stage was set for electrical communications to be used in the next European war.

Russia's Communications Problem

Ever since Peter the Great had unified Russia and proclaimed an empire in 1721, Russia's vast terrain posed a major communications dilemma. Catherine II ("The Great") and later Alexander I extended Russian political control over Poland and Lithuania and advanced Russia's boundary to the Crimea. Russia made gains in the Caucasus and Finland, colonized Alaska, and even founded settlements in Northern California. By 1850, Russia was the second largest empire in history, and it needed efficient lines of communication.⁶

In 1855, only two-sevenths of the inhabited world had roads, and these

were mostly in Continental Europe and the United States. With the exception of only a few main routes, such as St. Petersburg to Moscow, most of Russia had no roads or railways. "In general, the only practicable communications through this vast territory are effected in winter on the surface of the frozen snow by sledges. On the return of summer, when the snow has disappeared, the communications become extremely difficult, slow, and expensive."⁷ Efforts by Czar Nicholas I to modernize, such as initiating the St. Petersburg-Moscow Railway in the early 1840s, were intended to help improve Russia's overall economy, not its communications. But the country lacked sufficient capital and technical knowledge. And, outside of its major cities, it also suffered from a general lack of commercial spirit and free enterprise.⁸ Russia's government knew it needed to improve the modes of communication for strategic purposes, yet conditions outside of the major cities remained relatively primitive. Carriages operating on limited roads, couriers riding horseback, and waterways were inadequate for both transport and communication. Russia's great expanse, harsh climate, and varied terrain needed railroads and telegraph lines; but as the Crimean War approached, Russia had not constructed a single major railway and had only experimented with telegraphy.⁹

Whereas the United Kingdom and the United States relied upon private enterprise and invested capital from joint-stock companies or government-corporate partnerships to undertake major development projects, most

The Russian Imperial Telegraph

of Continental Europe and Russia depended upon government initiatives and directives. Construction projects were financially supported by government tariffs, not public stockholders.¹⁰ Russia therefore required an imperial decree and relied upon state credit to fund the enormous expenses—including the tremendous cost overruns that were incurred in the development of its railway and telegraph networks. This would have a long-term detrimental impact upon the impoverished nation's finances, since many decisions were made based upon political or strategic concerns rather than economic benefit.¹¹

Russia's Optical Telegraph

The first mention of any Russian governmental telegraph occurred in 1823 within papers of the Main Administration for Routes of Communication. Discussion focused on installing

an optical telegraph system similar to Claude Chappe's system in France. This system utilized a series of towers located on high ground—hence the name “telegraph hill”—having signaling apparatus that could be observed over several miles to relay coded messages (see Fig. 2).¹²

Pierre-Jacques Chateau established Russia's first optical line in 1824 between St. Petersburg and the Shlisselburg outpost on the Neva River. He extended the lines from St. Petersburg to the naval base in Kronstadt and to Warsaw. Descriptions of the optical stations appeared in the *Petersburgh Transactions*. Each station had a single arm, nine feet tall and one foot wide, with several cross pieces, each three feet long and one foot wide. The cross pieces were moved by a single chain that passed into the tower, operated like Venetian shutters.¹³ When war broke out in 1853, Nicholas I ordered construction of another optical line from Kronstadt to



Fig. 2. Russian semaphore telegraph station at Otschakoff in 1856. (Wilson, *The Old Telegraphs*, Plate 84).

Hanko in Finland to monitor northern naval operations in the Baltic.¹⁴ At its peak, the main network had 220 stations and reached the Austrian and Prussian frontiers through Warsaw. Each station operated with six employees, and the system had a general administration, which required 2,000 men overall for operation (see Fig. 3). It remained in use until 1854, linking the western Russian empire and its 66 million people for the first time.¹⁵

Russia's Electric Telegraph

Moritz Hermann Jacobi (1790–1874) conducted Russia's earliest notable experiments in electricity. Born in Potsdam,

he spent most of his life working at the Russian Academy of Sciences in St. Petersburg. Jacobi was renowned for his work in early electromagnetism and experiments with insulators. He designed an experimental needle telegraph in 1830 and installed a demonstration telegraph in 1832 spanning 18 miles between the St. Petersburg imperial residences. However, he never developed a practical working telegraph system.¹⁶

Baron Pavel Schilling (1786–1837), depicted in Fig. 4, was a Russian nobleman and diplomat in St. Petersburg who developed one of the first complete electric telegraph systems in the world. Schilling's experiments in his apartment began in 1892, and from 1830 to 1832 he demonstrated his system to Czar Nicholas I. The system used a binary code with an early single-needle indicator. In 1835, he installed an underground line around the Admiralty building. In 1836, the

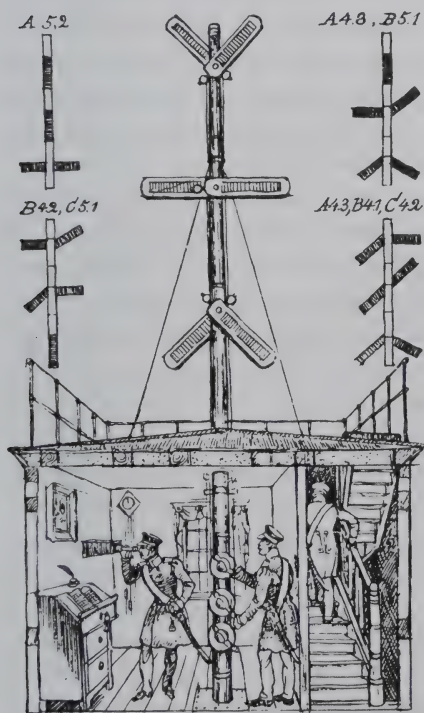


Fig. 3. Interior of Russian semaphore telegraph station, 1856. (Wilson, *The Old Telegraphs*, p. 161)



Fig. 4. Baron Pavel Lvovitch Schilling. (Wikicommons)

Czar ordered construction of a telegraph line from Kronstadt to St. Petersburg, which included a submarine cable in the Gulf of Finland, but Schilling died in 1837, and the project never progressed.¹⁷

The Moscow and St. Petersburg Railroad briefly operated a separate experimental subterranean telegraph line along its right of way, but the wire insulation failed. By 1850, Russia continued to lag far behind in its development of commercial or national telegraph communications.¹⁸ The principal problem facing both Jacobi and Schilling remained unsolved—namely the failure to find a satisfactory means of insulating the wires.¹⁹

As war approached, the situation could not have been more critical. British war correspondent William H. Russell wrote that the extent of territory and the state of internal communications made it difficult for Russia to concentrate troops, notwithstanding its compulsory conscription, levies, and enlistments.²⁰ Russia lacked adequate railways and its roads were incomplete. Visitors such as Werner von Siemens, who made his way to St. Petersburg in 1852, traveled by carriage, troika, and sledge over various post roads.²¹

By 1852, the government reported that efforts to “connect Petersburg with Moscow, and with the Russian ports on the Black Sea and the Baltic, are now in progress; other wires stretch from the capital of the Czar to Vienna and Berlin, taking Cracow, Warsaw, and Posen on the way.”²² But this was an optimistic assessment, since the contracts were not signed and construction of the lines had not even started.

In 1853, the Imperial government sought contractors, retaining the new German firm, Siemens & Halske, to install the first telegraph line between St. Petersburg and Kronstadt. It remained for Werner von Siemens and Johann Georg Halske to develop their system of electric telegraphy for wider Russian use.

Crimean Communications

When the Crimean War erupted, Russian generals dispatched Tatar and Cossack couriers across the Ukraine to Moscow or utilized the optical semaphore system for communications. Short messages could traverse the entire distance from Sevastopol to Moscow in approximately two days. Electric telegraph lines were then employed to communicate between Moscow and St. Petersburg.²³ Thus, a complete round trip communication, including a command or decision, could take five to seven days.

In comparison to the Russians, the British and French relied upon a mixed system of couriers and message deliveries by steamer from the Crimea to Varna, which took from twelve days to three weeks to reach Paris or London. In 1854, the British formed a Telegraph Detachment for the Army with 25 men from the Royal Corps of Sappers and Miners under the command of the Royal Engineers. The following year, the British and French governments developed portable electric telegraph wagons and temporary stations that could reach new submarine cables that extended across the Black Sea to Varna, which then linked to the various European state and business telegraph networks that connected to Paris

and London. This reduced their message delivery times to 24 hours.²⁴

The Ottoman Empire entered the war with no telegraph system. Soon after the war started, the Austrian telegraph lines were extended from Hungary through Belgrade, reaching the Turkish frontier, and a French company continued the line on to Constantinople.²⁵

Despite the rapid pace at which the Russian Imperial Telegraph would be installed, the network built by the Allies ultimately proved faster and more advantageous. Nevertheless, installation of the Russian telegraph network was now critical.

Origins of Siemens & Halske

Ernst Werner Siemens (1816–1892, later Werner von Siemens) was the fourth of fourteen children. He was the eldest of three highly successful brothers, the others being Carl Heinrich Von Siemens (1829–1906), who was known for his Russian work, and Wilhelm Siemens (1823–1883), who was known as William Siemens after he moved to Britain, and was later knighted for his work there. Werner Siemens entered Prussian military service in 1834 to get an education after the death of his parents. Three years of officer training at the Prussian Military Academy gave him a background in applied engineering, which led to an assignment at the Artillery and Engineering Academy in Berlin. He was introduced to mechanical, electrical, and chemical sciences through his work on gunpowder detonation systems and his invention of a method for detonating electrically charged sea mines. Siemens

obtained his first patent in 1842 for an electrolytic method of gold and silver plating. By 1844, the Prussian government began investigating the new electric telegraph systems being developed in the United States and Great Britain and ordered Siemens to explore ways to increase transmission speeds for military and government signaling. This work introduced him to the study of electricity, Cooke and Wheatstone's experiments with telegraphy (see Fig. 5), and Morse code. In 1845, Siemens solved a current synchronization problem between the transmitter and receiver that plagued the early dial telegraph systems. Siemens's invention automatically synchronized the movements of the transmitter and receiver, providing a dramatic improvement over the clock-type mechanisms used by Wheatstone. Since Morse, Cooke, and Wheatstone

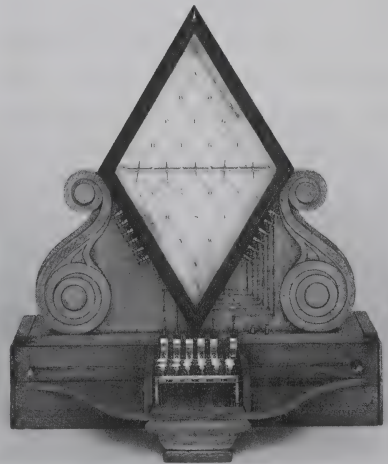


Fig. 5. Cooke and Wheatstone's first five-needle dial telegraph, 1837. (Science Museum, Object No. 1876–1272)

The Russian Imperial Telegraph

had no telegraph patents in Germany, Siemens was free to commercialize their findings. He obtained a patent on his own dial and printing telegraph system in 1845. The next year, he served on a Prussian military commission responsible for introducing electric telegraphy throughout Prussia.²⁶

Siemens first met Johann Georg Halske (1814–1890) when they participated as founding members of the Berlin Physical Society. Halske attended a prestigious secondary school in Berlin, the *Gymnasium zum Grauen Kloster*. He apprenticed for a highly regarded machine builder named Schneggenburger and a premier astronomical instruments maker, Johann Georg Repsold. Then he worked with Berlin's most famous precision mechanic, Carl Philipp Heinrich Pistor. By the time he met Siemens, Halske had become a skilled craftsman who was producing scientific and test equipment at his own workshop in Berlin.²⁷ The two were a study in contrasts: Siemens was a visionary entrepreneur, risk taker, and industrialist, while Halske was a precision mechanic focused on design

and the art of creating fine instruments, and a very conservative businessman.²⁸ A third key member would join them soon, Carl Siemens. The three of them are pictured in Fig. 6.

Together, Siemens and Halske opened a small workshop in a rented house in Berlin, and in 1847, the two founded the *Telegraphen Bau-Anstalt von Siemens & Halske*, which appears on the letterhead reproduced as Fig. 7. (The Siemens & Halske Telegraph Construction Company is Siemens AG today.) Halske oversaw the day-to-day operations of their factory and designed and built much of the electrical apparatus and equipment, while Siemens chased opportunity, political and military contacts, and dreamed up his own ideas and designs.²⁹ The following year, the now ten-man firm received a contract to install a telegraph line between Berlin and Frankfurt/Main. They completed it in time to announce the March 28, 1849 election of King Friedrich Wilhelm IV of Prussia as German Emperor, gaining important publicity and recognition for the company. The firm's successful



Fig. 6. (L to R) Johann Halske, Carl Siemens, and Werner Siemens. (Siemens Collection)



Fig. 7. Siemens & Halske letterhead, 1853. (Siemens Collection)

start enabled Siemens to resign from the military in 1849.³⁰ Siemens and Halske were now able to focus on developing an entire telegraph system including relays, lightning arresters, glass insulators, insulating materials.³¹

The First Russian Telegraph Contract

In Europe, popular unrest and revolutions, beginning in 1848, prompted governments across the continent to accelerate their development of telegraph systems. The international industrial exposition in London in 1851 at the Crystal Palace brought more than 17,000 exhibitors who displayed their inventions and machines. Siemens & Halske represented Germany, showing their telegraph instruments and railway signaling systems. The firm received international acclaim when they won

the Council Medal, the highest award, for their dial-pointing telegraph.

Siemens & Halske attracted attention in Russia through Captain Carl von Luders in the Russian Telegraph Administration. Luders reported to Count Piotr Andreievitch Kleinmichel, Chief of the Ministry of Public Ways and Communications, who was responsible for awarding Russian government telegraph contracts. Luders was a German-speaking nobleman with an engineering background, and the Czar had sent him across Europe to study the various systems of telegraphy under development. At Luders's suggestion, Siemens & Halske demonstrated their system in St. Petersburg as a means of regulating the railway. Luders did not envision non-railway use of the telegraph for private or governmental communications. He reported that failed insulation

The Russian Imperial Telegraph

on subterranean line installations had been a key problem. After only two visits, Siemens & Halske received a contract to construct a dial telegraph line from St. Petersburg to the naval base at Kronstadt.³² When they completed the submarine cable portion of the line in 1853, it was the first permanently serviceable telegraph line in the world. The underground and submarine telegraph line relied upon a new device, a gutta-percha press developed by Siemens and Halske and first successfully tested in 1848 (see Fig. 8). The press applied a seamless watertight coating of insulation to the wire during manufacture, which allowed the wire to survive hostile environmental conditions.³³

Siemens & Halske's pointing telegraph was radically different than other systems since the transmitter and receiver were identically designed (see Figs. 9 and 10).³⁴ The wooden case contained a galvanometer (lower left), a switch (above the galvanometer), the twelve-inch diameter telegraph with dial and petal keys (right), and an internal alarm. In 1851, the firm

supplied 75 dial telegraphs for use in 33 stations that would be operated by 192 men on the telegraph line from St. Petersburg to Moscow. Since the Russian government retained responsibility for constructing the telegraph lines, they supplied only the apparatus. The complete system was not finished until October 1853, largely due to delays in constructing the station buildings. At the time, the 400-mile railway and telegraph line was the longest under one administration in Europe.³⁵

This telegraph would later serve as a model for designing Siemens & Halske's 1856 Magneto Dial Telegraph (see Fig. 11), which indicated the alphabet on its dial by turning the handle. An exposed bell alarm on the top could switch between bell and telegraph. It used no galvanic cells, generating its current by turning a novel double-T armature. This telegraph was used on the Bavarian telegraph lines in southern Germany, larger municipal city lines in Europe, and later Russian railroad telegraph lines.³⁶

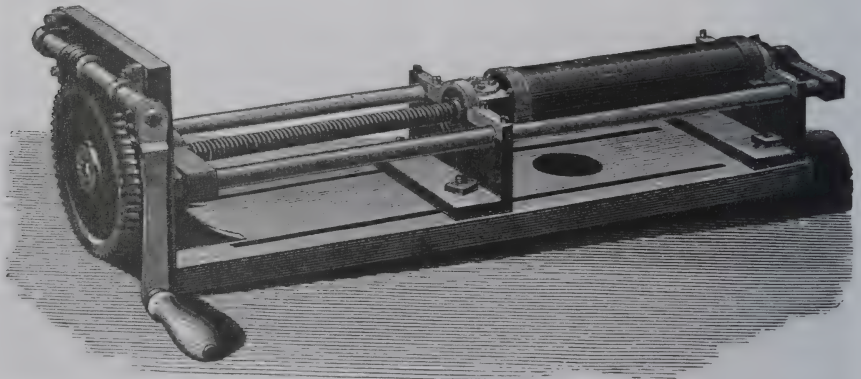


Fig. 8. Siemens & Halske's gutta percha press. (*Scientific and Technical Papers of Werner von Siemens*, 1895, p. 76)



Fig. 9. Isometric view of a replica of Siemens & Halske's improved dial/pointing telegraph. (Siemens Collection)

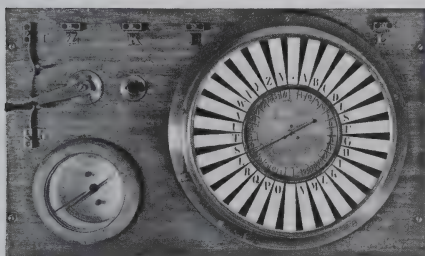


Fig. 10. Top view of a replica of Siemens & Halske's improved dial/pointing telegraph. (Siemens Collection)



Fig. 11. Siemens & Halske's magneto-electric pointing telegraph installed in Bavaria. (Schellen, 1888, p. 436)

Distance and Language Problems

As a result of their success, Siemens & Halske were contracted to install overhead telegraph lines from Moscow to Svastopol via Kiev, and between Warsaw and St. Petersburg (see Fig. 12).³⁷ The firm deployed their newly-designed automatic telegraph system beginning with the Warsaw line.³⁸

The construction conditions were particularly challenging. Each year the spring thaw would loosen the ground, causing the telegraph poles to fall down, and the bridges and roads became impassable for transporting materials for repairs. All materials had to be obtained from Berlin or Western Germany, and the few existing roadways were routinely occupied by, or ruined by the impact of, military transports. They faced numerous obstacles: an absence of railways,

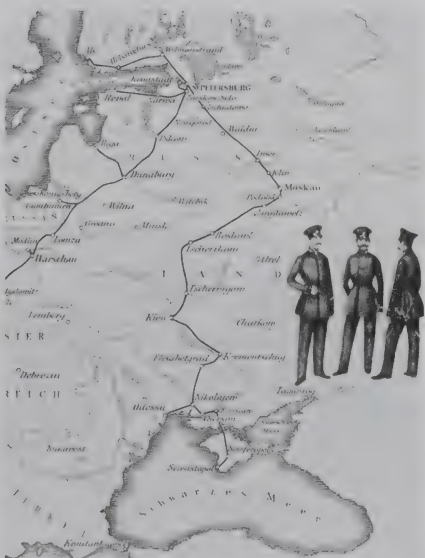


Fig. 12. Map of the Russian Imperial Telegraph, 1855. (Siemens Collection)

so the materials were transported by horses; an absence of a literate population and skilled personnel, so all skilled workers were brought in from abroad; and a lack of local laborers, so regional and local villages had to be individually cajoled or conscripted into service.³⁹ They also faced a general environment of governmental mismanagement, bureaucratic inefficiency, and corruption within a feudal, impoverished nation dominated by serfs.⁴⁰ Considering the obstacles, completion of the telegraph in so short a time frame was actually a tremendous feat.

General von Luders, now Director General of the Russian Imperial Telegraph, described the Russian Imperial Telegraph to George Sauer, a former U.S. Consul in Brussels, in the mid-1860s.⁴¹ Distances were tracked in Versts (or Wersts), the early Russian Imperial measurement, rather than the French metric or old English systems. A Verst is approximately 1.07 kilometers, 0.66 miles, or 3,500 feet. The telegraph poles (posts) were young firs standing about 25 feet tall and placed approximately 220 feet apart, or 18 per mile depending on the terrain. Ornate iron pillars were used in the cities rather than the fir poles. The porcelain insulators, which ranged in size from 3 to 5 inches, resembled the Prussian designs of Major General Chauvin, which had a double-bell shape. The telegraph utilized No. 6 and No. 8 non-galvanized wire coated in boiled linseed oil. Sauer noted the immense distances in Siberia, where the line from Kasan to Irkutsk and Kiachta traversed 2,800 miles without touching a single city. This

line, installed after the Crimean War, exemplifies the distances involved in Russian telegraph lines.⁴²

Russian telegraph systems utilized both the Latin alphabet and commonly accepted Morse code symbols for English, French, or German, as well as the Cyrillic alphabet for native Russian. The Russian language, composed of 36 letters, was reduced to the telegraphic alphabet of 30 letters shown in Fig. 13, where the arrangement of dots and dashes was economized and phonetically matched as best as possible. For example, the Russian B was similar to the English V and German W, and all used a dash-dot Morse code combination. Generally, Russian telegraphic punctuation conventions were copied from the European Morse telegraph system.⁴³

THE RUSSIAN MORSE ALPHABET			
А	· —	Ф	— — — ·
Б	· — · —	Х	· — — —
В	— ·	Ц	— — —
Г	— — · — ·	Ч	— — —
Д	— —	Ш	— · — —
Е	· ·	Щ	— — — —
Ж	— — · ·	Ъ	· · · ·
З	· — — —	Ы	— — — —
И	· · ·	Ю	· · · —
К	— — · — —	Я	· — — —
Л	· · · —	П	· — —
М	· — — ·	Р	· · —
Н	—	С	· · ·
О	·	Т	— — —
		У	· — —

Fig. 13. The Russian language, composed of 36 letters, was reduced to the telegraphic alphabet of 30 letters where the arrangement of dots and dashes was economized and phonetically matched as best as possible. (Shaffner, 1859, p. 476)

New Telegraph Instruments

In 1854, Siemens and Halske replaced their original dial telegraph system with a new automatic “writing system” that employed a three-key perforator (see details below) to punch Morse code onto a paper tape for transmission through a “quick sending instrument.” The operators prepared the punched paper tape as shown in Fig. 14 and fed it through the instrument shown in Fig. 15, thus enabling the system to work much faster than hand-keying or dial reading. Signals were received and recorded by the “rapid printer” shown in Fig. 16. Use of an early form of duplex telegraphy allowed simultaneous sending and receiving of messages through a single wire. The extension of Russia’s imperial network to the Crimea was the first time this new system was deployed.⁴⁴ As one newspaper noted, “The introduction of simple mechanical devices has enabled not only considerable savings to be made in the maintenance of batteries but also the telegraph and signaling apparatus to be effectively protected against the injurious effects of atmospheric electricity.”⁴⁵

The telegraphs deployed in Russia used Morse-type receivers that embossed the paper tape with a steel point as the signal arrived. These relief writing systems were later replaced with ink printing. Siemens’s use of horizontal coils in the 1851–1852 registers enabled up to 300 characters per minute to be received. The Siemens three-key punch shown above, which was similar to Wheatstone’s concept, was used to prepare the paper tapes for transmission in the express sender. The left key recorded dots by

making a single hole in the tape, and the middle key recorded dashes by making two holes in the tape. Each time a key was depressed and made its hole, the paper advanced. The double holes

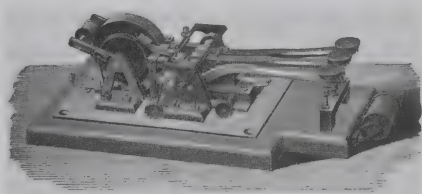


Fig. 14. Siemens & Halske’s three key perforator/punch, 1855. (*Scientific and Technical Papers*, 1895, p. 97)

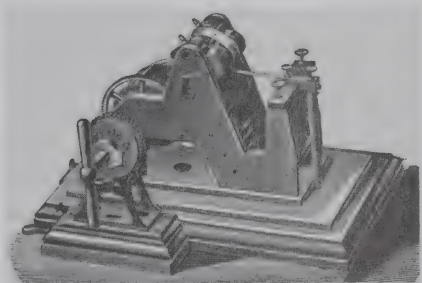


Fig. 15. Siemens & Halske’s express telegraph reader (transmitter), 1855. (*Scientific and Technical Papers*, 1895, p. 98)

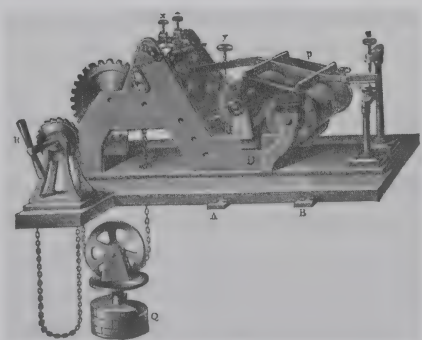


Fig. 16. Siemens & Halske’s express telegraph writer (receiver), 1855. (*Scientific and Technical Papers*, 1895, p. 98)

The Russian Imperial Telegraph

corresponded to a longer electrical pulse on the line forming the dashes and distinguishing them from the shorter pulses that formed the dots. The third key made no holes but simply advanced the paper, providing spaces to separate the Morse characters.⁴⁶

Siemens and Halske also designed a unique new insulator for the Russian telegraph lines. Insulators used on continental systems were generally made of glass, porcelain, or burnt clay. They were fragile and easily broken, and they cracked and absorbed water, causing a loss of current or creating short circuits. Siemens and Halske developed the bell shaped insulator shown in Fig. 17, which was protected by an iron shield that greatly improved the durability and effectiveness of insulators. Their design was positively received and generally accepted across the industry.⁴⁷ Later insulators were manufactured by the famous porcelain works at the Kuznetsov Factory near Riga, Latvia. In 1843, Sidor Kuznetsov founded the factory to manufacture faience crockery.⁴⁸ In 1851 the factory began to produce porcelain, including the Russian Empire's telegraph insulators, such as the one shown in Fig. 18.⁴⁹

Subterranean lines were also used. Russia's first experimental line between Moscow and St. Petersburg along the 400-mile railway began as a subterranean system; this failed and was replaced by overhead lines erected on telegraph poles. Siemens concluded that overhead lines were generally superior to underground lines or submarine cable;⁵⁰ however, telegraph lines through the cities continued to have subterranean sections.

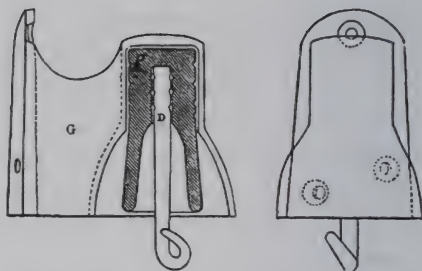


Fig. 17. This Russian Imperial Telegraph insulator was housed in a cast iron body (G) with a glass or porcelain insulator (P) and a wire supporter (D). (Shaffner, 1859, p. 554)



Fig. 18. Kuznetsov Russian Imperial Telegraph porcelain insulator, 1870s. The insulator carries the Imperial Russian Double Eagle and initials of the telegraph office. (Authors' Collection)

Siemens & Halske also had to contend with crossing some of the widest rivers in Europe. This required taller telegraph poles to support the overhead wires, as many rivers were selected for overhead lines rather than submarine cable. The river Niemen at Kovno in Russia required an expanse of 1,700 feet from pole to pole, the longest in Europe at the time.⁵¹

In addition, monitoring stations were installed every 50 kilometers (31 miles) along the lines. Each station had service personnel and measuring equipment, in particular a Siemens & Halske control galvanoscope, developed in 1855. These stations made it possible to quickly locate and repair problems within a few hours, helping to ensure the telegraph system's overall reliability.⁵²

Success

Within two years, in 1855, the major lines were operating, spanning 10,000 km (6,214 miles). Under Carl's management, Russian business activities developed to such an extent that within those two years they became the centerpiece of the entire company. The Russian telegraph system was now generating 80 percent of Siemens's total revenue. The firm grew from 10 employees to 332 by 1856 with two-thirds of them working in Russia.⁵³

The Russian Imperial Telegraph now linked St. Petersburg to Moscow, Warsaw, Kiev, Odessa, and Sevastopol. Russia also joined the Austro-German Telegraph Union the previous year in order to send telegrams outside her borders.⁵⁴

The rapid completion of the Russian Imperial Telegraph was quietly celebrated in Russia and in Berlin. Broader recognition was muted by the ongoing debacle of the Crimean War. In Berlin, a detailed heliogravure of a lithograph appeared in 1855 in Gustav Schauer's *Atelier für Photographie u. Lithographie* (see Fig. 19).⁵⁵ The artwork itself is one of the earliest combinations of photographic reproduction, lithography, and heliogravure reproduction techniques, and it is among the earliest formal depictions of electric communications history.⁵⁶

The success of the entire system depended upon Carl Siemens, Werner's brother. Carl attended the Katharineum, the city of Lübeck's oldest gymnasium secondary school, before living with his brother Werner and entering the business in 1849. Carl learned telegraphy working on Siemens's installation of German telegraph lines. He travelled to St. Petersburg in 1853 to personally supervise the Russian installation work. That year, the company began managing operations via Kiev, Odessa, St. Petersburg, and Moscow. Carl spent most of the rest of his life living in Russia directing the firm's Russian businesses.⁵⁷

Dynamic growth put the relationship between Berlin and St. Petersburg on an entirely new footing. On January 1, 1855, the 26-year-old Carl officially joined the firm's top management as a shareholder, after which the St. Petersburg engineering office became a separate foreign subsidiary. Later that year, the Czar appointed Siemens & Halske to maintain their newly installed telegraph lines until 1867.⁵⁸



Fig. 19. Commemoration of the Russian Imperial Telegraph in Gustav Schauer's *Atelier für Photographie u. Lithographie*, 1855 with Werner Siemens (left) and Georg Halske (right). (Authors' collection)

Government Versus Private Interests

Russia's telegraph network was government owned and operated under the minister of public buildings, ways, and communications. Private contractors, notably Siemens & Halske, constructed the system and surrendered the lines to the government upon completion. Private ownership of the network was not permitted.⁵⁹

The system depended upon a complex assignment of foreign and domestic tariffs to financially support itself, and used message seals such as those shown

in Fig. 20. Private citizens could send messages for private and commercial affairs without restriction; however, considerable administrative rules applied. Telegrams were classified by sender: royal family, government, administrative, ministerial relating to public buildings and communications, and private. Royal messages took priority. Operating room access was restricted to official employees, and telegraph messages could only be sent and received from the official stations. Foreign dispatches, and those from St. Petersburg to Warsaw, Helsingfors, Cronstadt, Dunaburg, and



Fig. 20. Russian Imperial Telegraph message seals for the Main Postal and Telegraph Office, 1870s. (Authors' collection)

Riga, could be transmitted in French, German, Russian, or English. Dispatches from the interior were required to be in Russian. Political dispatches were prohibited. Royal and government dispatches were unlimited. Private dispatches were restricted to 100 words unless the line was not being employed, but were subject to review by the station director for content.⁶⁰ In addition, Russia utilized the growing telegraph system to begin standardizing and regulating time. All clocks along the network were synchronized to St. Petersburg royal time each day.⁶¹

Assessing the Impact

During the war, the French built an electric telegraph line from Varna to Budapest to connect with the Austrian system, linking the British submarine cable from the Crimea to the European electric telegraph network. Yet the French still sent over 4,500 messages from the front using Chappe's optical telegraph system. The last general message sent by optical telegraph announced the capture of Sevastopol by the Allies in September 1855. The remaining stations were closed, the equipment was scrapped, and the lines were abandoned.⁶² It was clear that

electric telegraphy now dominated the world of rapid communications.

As a result of the availability of the electric telegraph, commanders in the field on both sides of the war were, for the first time, subject to instructions from headquarters in distant capitals. However, postwar assessments indicated the telegraph had little actual impact on the battlefield.⁶³ Yet, losses like the famous Charge of the Light Brigade that resulted from bungled and unclear courier messages did lead to conclusions that electric telegraphy could greatly improve overall military communications. Napoleon III did not hesitate to relay instructions to his generals, rebuke French commanders for battlefield losses, and congratulate them on the victory at Sevastopol in September 1855.⁶⁴ The British government overburdened its commanders with suggestions, recommendations, and requests for useless information.⁶⁵ British General Sir James Simpson, who resigned by telegraph in September 1855, concluded that the telegraph was a new factor in warfare.⁶⁶ Still, tactical communications remained haphazard, depending on runners and dispatch riders, clumsy telegraph apparatus, and vulnerable telegraph lines. Further development would be necessary for the telegraph to become a true instrument of war.⁶⁷

By 1860, telegraph installations worldwide were still somewhat limited in scope, with the greatest mileage of lines in one country located in the United States (see Table 1). It took the American Civil War to fully demonstrate how telegraphy could be effectively used in battlefield strategy and tactics. As a

TABLE 1. TELEGRAPH MILEAGE, 1860	
United States	50,000
Great Britain & Ireland	40,000
Germany	35,000
France	26,000
Russia	12,000
Italy	6,600
Switzerland	2,000
Denmark & Sweden	2,000
Belgium	1,600
Spain & Portugal	1,200
Turkey & Greece	500
Avg. Station Distance 10-12 Miles	
<u>Data:</u> Prescott, <i>History, Theory & Practice of the Electric Telegraph</i> , (Boston, Tichnor and Fields, 1860), p. 215.	

result of the American Civil War and the growing application of telegraphy to manage European wars, such as the Franco-Austrian War of 1859, the Austro-Prussian War of 1866, and Franco-Prussian War in 1870–71, the United States and European powers established telegraph and signal training schools, fully integrating them into their military communications and leadership structures. By the late 1860s, a “general staff” who communicated via telegraphy was increasingly favored.⁶⁸ Nevertheless, telegraphy’s importance in the field, as opposed to strategic use between armies and headquarters in the rear, continued to be limited by the locations of existing or temporary installations, line capacity, and the inconvenience of bulky equipment.⁶⁹

The results in Russia were very different. The war left Russia significantly weakened. The cost of resupplying military depots combined with a poor economy and dependence on serfs for

troops and production left Russia unable to rapidly mobilize.⁷⁰ Russia had not expanded its railroad network in time to supply Sevastopol. Its telegraph network actually stopped in Simferopol, 50 miles away from Sevastopol. And, its bureaucracy was incompetent and riddled with graft and corruption.⁷¹ Russia actually experimented with a field telegraph in 1854 that consisted of two apparatuses in two carriages but never used it in combat, despite having it on the front.⁷²

After the war, Czar Alexander II embarked on a period of reform, including the Emancipation of the Serfs, military and bureaucratic reorganization, and a commitment to improve Russia’s telegraph system.⁷³ The Franco-Prussian War in 1873 again highlighted the War Ministry’s need to improve its military organization and its telegraph networks.⁷⁴

Ongoing underdevelopment of Russia’s railway systems meant that installation of the telegraph network actually preceded development of railroads. Unlike the American experience, where railroads and telegraph grew together, Russia’s strategic need to link a vast terrain and its limited resources for capital meant that telegraph projects remained an unfulfilled priority.⁷⁵

Siemens in Russia After The War

In 1856, all of Siemens & Halske’s revenues derived from telegraphy sales, with 70 percent originating from foreign contracts, mostly in Russia.⁷⁶ Due to the extraordinary importance of Siemens & Halske’s business in Russia, Carl took up permanent residence in the country after the war. He married the daughter

of a St. Petersburg businessman of German descent, and in 1858 he obtained Russian citizenship. Over the decades to come, Carl established a number of companies in Russia.⁷⁷

Carl oversaw the company's lucrative "Remonte" contracts for maintaining the Russian Imperial Telegraph from 1855–1867. The Russian government intended to maintain the lines itself, but their workers lacked technical knowledge, and they were unable to manage the long distances and extreme weather conditions.⁷⁸ Siemens & Halske maintained the network as the "Contractor for the Construction and Maintenance of the Imperial Russian Telegraph Lines." The firm's employees were granted the status of Russian civil servants and wore uniforms with badges of rank (see Fig. 21). In 1867, Count Kleinmichel resigned, and the firm lost its key sponsor within the Russian government. The



Fig. 21. Siemens & Halske's Russian telegraph employees, 1860s. (Bahr, *Lifelines*, 2016, p. 30)

impoverished government, still reeling from the financial impact of the Crimean War, planned no further investments in the telegraph network and assumed responsibility for maintenance.⁷⁹

In 1882, Carl constructed a cable plant and electro-technical plant in St. Petersburg (see Fig. 22). In 1886, he installed lighting systems in St. Petersburg and Moscow. Two years later, Siemens & Halske electrified Moscow and constructed the city's first power station. In 1898, he founded the "Association of Russian Electrical Plants of Siemens & Halske" in St. Petersburg. Carl was raised with the privileges of the hereditary Russian nobility by Czar Nicholas II in 1895 in recognition of his services industrializing the country.⁸⁰

All three brothers were now recognized for their work. Werner received his ennoblement by the German Emperor Frederick III in 1888. William Siemens, a member of the Royal Society and the first chairman of the Society of Telegraph Engineers and Electricians, was knighted for his work in Great Britain by Queen Victoria before his death in 1883.⁸¹ Meanwhile, their global enterprises continued to prosper and diversify. The British company, Siemens Brothers, designed the first special purpose cable-laying ship, CS *Faraday*, which laid five Transatlantic cables. The firm also organized and constructed the Indo-European telegraph lines.⁸²

However, Halske tired of the politics and management. The original workshop in Berlin grew into a large factory, and the business now had multiple locations. The acceleration and mechanization of



Fig. 22. Siemens & Halske's St. Petersburg Works, 1882. (Siemens Collection)

production conflicted with his perfectionism and his craftsman's orientation. As Siemens pressed for ways to streamline designs and increase production, the firm also took significant financial risks. The turbulent expansion was too much for the conservative Halske. His contributions were crucial to designing most of the telegraph instruments, but in 1867 he withdrew from the firm, leaving his capital invested as a loan. He joined the Berlin city council and worked to establish a Museum of Decorative Art. He remained friendly with Siemens and supported the company, helping manage its pension fund until he died in 1890. Five years earlier, German Emperor Wilhelm I had awarded him the Order of the Crown, Third Class.⁸³

Werner followed Halske, passing away in 1892 from pleurisy. He left the firm in the hands of Carl as senior partner, and his two sons. At

the time of his death, the firm employed 6,500 people worldwide.⁸⁴ Carl continued to manage the firm, finally passing away from pneumonia in 1906.⁸⁵ At the end of the 19th century, Siemens & Halske celebrated its 50th anniversary by issuing the medals pictured in Fig. 23. It now operated the largest single factory building not only on Berlin but also in Europe. The firm eventually became a massive worldwide operation, and upon its 170th anniversary in 2017, it had 372,000 employees working in every country on earth and €83 billion in revenues.⁸⁶



Fig. 23. Siemens & Halske 1847-1897 50th Anniversary Medal. (Authors' collection)

Russian Telegraphy After The War

Czar Nicholas I reigned from 1825 to 1855. Trained as an engineer, he originally decreed that Russia's major cities should all be linked by telegraph. Nicholas I died of pneumonia in March 1855. His successor, Czar Alexander II, largely completed the task by the time of his assassination in March 1881. St. Petersburg installed its city telegraph in 1857, Moscow followed by 1861, and Kiev by 1881.⁸⁷

Although Russia's telegraph lines to the Crimea were not completed until 1855, they did enable Russian authorities to control the movement of troops and materiel, and to order shipment of heavy military goods from Berlin.⁸⁸ The experience helped stimulate a desire to expand the telegraph network as a means to push reforms under Alexander II. Many reforms did occur in the 1860s and 1870s, including industrialization and improved communications. Yet Russia remained a bureaucratic state with a prevailing mistrust of new inventions.⁸⁹ Projects directed by the government were typically slow to complete. For example, the original St. Petersburg-Moscow Railway did not open until 1851, years behind schedule, and the last item completed was the telegraph line.⁹⁰

The Russian government even looked to the United States for guidance, based on American success with its transcontinental telegraph over similar varieties of terrain and remote expanses. Efforts to build the Trans-Siberian telegraph prospered and languished for periods, but were ultimately successful in linking Vladivostok to Moscow and

St. Petersburg by 1872, with a second line installed by 1876.⁹¹ Russia's first public-private investment entity, the new Danish consortium Det Store Nordiske Telegraf-Selskap (Great Northern Telegraph Company), funded construction of the Trans-Siberian line.⁹² And in 1875, Russia hosted the International Telegraph Union and oversaw its St. Petersburg Telegraph Conference, which redrafted the International Telegraph Convention agreements. The next conference would not be held until 1932.⁹³

Russia's telegraph network grew from 4,840 miles in 1857 to 23,235 miles ten years later—expanding station offices from 79 to 345. The network gradually extended from Irkutsk, the capital of Eastern Siberia, to Vladivostok, the location of Russia's new Pacific naval base. Separate lines reached connections that linked Peking and extended through Mongolia to the Punjab and the British Indian system. A final line went through Georgia along the western Caspian Sea to Tehran, the capital of Persia.⁹⁴

By the mid-1880s, the directory listing of telegraph stations in Russia spanned 160 pages. By the close of the 19th century, all of Russia's major cities were linked by telegraph.⁹⁵ Russia also possessed the second largest railway system in the world, due mainly to the distances involved rather than the density of operations.⁹⁶ Telegraphy and railroads together were improving communications across the country. As the century ended, Russia was sending 18 million telegraph messages annually over 93 thousand miles of telegraph lines (see Table 2).

Despite all the efforts and the dramatic distances involved, Russia remained a distant fifth in its use of telegraphy, sending just over one-fifth the amount of message traffic as Great Britain and about one-quarter the amount of message traffic as the United States (see Table 3). With a population exceeding

131 million, Russia was sending only one message for every seven people at the turn of the century.⁹⁷ And 75 percent of the system mileage and stations were still operated by the government, with only 23 percent operating on railway lines and 2 percent held by privately-owned companies.⁹⁸

TABLE 2. RUSSIAN IMPERIAL TELEGRAPH

<u>Year</u>	<u>Miles of Lines</u>	<u>No. Stations</u>	<u>Total Messages</u>
1850	0	0	0
1860	10,904	160	401,479
1870	29,234	714	2,716,331
1880	58,801	2,623	7,262,555
1890	76,120	4,035	11,021,243
1898	93,070	5,257	17,595,216

Data: (1) 1860 based on Sauer, 1869, Tabular Statements, p. 9; (2) 1860-1898 based on Statistical Abstract for the Principal and Other Foreign Countries, Her Majesty's Printing Office, Tables 22,24,26, various years. Note, data after 1898 not reported.

Notes: Miles of wire used are significantly larger than the miles of lines. No. of stations includes state owned and railway offices. Total messages include domestic and international services.

TABLE 3. GROWTH IN TOTAL MESSAGES FOR TOP FIVE TELEGRAPH NETWORKS AFTER 1860

	<u>Russia</u>	<u>France</u>	<u>Germany</u>	<u>U.S.</u>	<u>U.K.</u>
1860	401,479	720,250	801,627	5,000,000	1,863,839
1870	2,716,331	5,663,800	8,207,800	9,157,646	9,850,000
1880	7,262,555	17,134,000	16,312,457	29,216,509	29,967,000
1890	11,021,243	31,076,000	27,020,974	55,878,762	66,409,000
1900	19,708,000	40,097,000	46,008,795	79,696,227	89,577,000

Notes: (1) U.S. includes Western Union and Postal Telegraph. (2) Great Britain's tremendous growth is due largely to ocean cables carrying international and empire messages.

Data: (1) 1860 except U.S. based on Sauer, 1869, Tabular Statements; (2) 1860-1900 based on Statistical Abstract for the Principal and Other Foreign Countries, Her Majesty's Printing Office, Tables 22, 24, 26 for various years. (3) U.S. 1860 based on "Progress of the Electric Telegraph," *The Atlantic*, March 1860.

Siemens's Own Perspective

Forty years after the Russian Imperial Telegraph reached the Crimea, Werner von Siemens offered his view of the outcome. Siemens died in 1892, just before his 76th birthday, at his villa in Charlottenburg located outside of Berlin. His autobiography had been finished only days earlier (see Fig. 24). The *Personal Recollections of Werner von Siemens* presented a straightforward perspective on his life's successes and failures.⁹⁹ Siemens stated:

"The speedy construction . . . [was] all completed after overcoming infinite difficulties in the years 1854 and 1855, and were of great utility to the Russian empire in the Crimean war raging at the time. By means of the telegraphs Russia was put in speedy

communication with Berlin and the west of Europe: in the interior of the empire the movement of troops and material could be regulated with their help, and the central government could everywhere promptly make and improve its arrangements."¹⁰⁰

What Hath God Wrought?

The longer-term impact of the Russian Imperial Telegraph would have tremendous implications for Russia and the world. Samuel Morse's flamboyant declaration, "What Hath God Wrought," can be considered within a different context for Russia.

Linking the empire, improving communications, and tightening military management and bureaucratic controls led to ever increasing levels of autocracy. Over the next fifty years, the government struggled to implement reforms and then resisted demands for extension of those reforms. Some of the first messages sent on the original St. Petersburg-Moscow line involved government orders for the relocation of detainees and soldiers. Czar Nicholas I was fascinated by the idea of using railways and the telegraph to relocate the army and suppress revolts. Czars Alexander II and III and Nicholas II all used these means to suppress uprisings in Poland and across Russia's western interests. The Czars also struggled to establish territorial unity over the many ethnic groups facing eastward across Siberia toward the Pacific.¹⁰¹

Together, the electric telegraph and the railroads inadvertently opened the door to an increased flow of information from the outside world, permitting

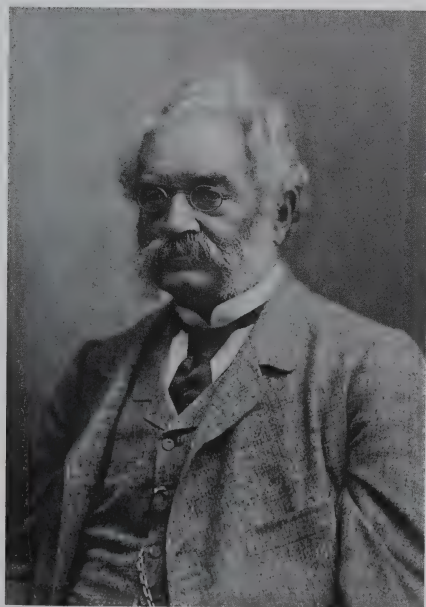


Fig. 24. Werner von Siemens, 1892. (Siemens, *Recollections*, 1893, cover plate)

increased communication within Russia by those calling for reforms, spreading propaganda, and, later, revolution.¹⁰² These two opposing forces—growing imperial autocracy and accelerating demands for reform—ultimately eroded Russia's feudal management structures and tore the country apart. The nation's telegraph lines were destroyed in street protests and used as barricades, then were restored by either the government or revolutionaries to suit their needs.¹⁰³ It is indeed ironic that the Crimean War, which spurred the growth of Russian telegraphy in the 19th century, helped lay the seeds for future revolution and the ultimate collapse of Imperial Russia in the early 20th century.

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David and Julia Bart

Preserving the Story of Greater Boston's Pioneering Broadcast Stations 1XE and WGI

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Station 1XE, later known as WGI and then WARC, was also known as “the AMRAD station.” But by any name, it was one of the first radio stations in the United States to broadcast voice and music, beginning in 1916. It had one of radio’s first women announcers; it offered some of the first regular newscasts; and in early 1922, it began providing college courses by radio. The AMRAD station was also home to many of greater Boston’s best-loved entertainers and announcers, some of whom went on to national fame. Yet today, this pioneering radio station is all but forgotten. Media historian Donna Halper takes a closer look at the AMRAD station’s history, discussing its important role in early broadcasting, and why it deserves to be remembered.

Station 1XE, later known as WGI in 1922 and WARC in 1925, was a pioneering radio station and one of the first in the United States to broadcast voice and music. The station was often called the “AMRAD station” because it was owned by the American Radio and Research Corporation, which manufactured radio receivers and other amateur radio equipment, and had roots that could be traced back to 1915.¹ Some people who worked there believed it was *the* first station, and during the early 1920s, the station often used the slogan “Where Broadcasting Began.”² While historians continue to debate which station was the first commercial station ever to broadcast, it is a fact that this station was one of the first licensed stations in greater Boston, and it is believed to be the first station in Boston to broadcast voice and music. This often comes as a surprise, because

when most people think of Boston’s radio history, the name of WBZ-AM immediately comes to mind. Certainly, WBZ is a station with a storied history, and its longevity is impressive (it went on the air in mid-September 1921, and still uses the same call letters), but it was not the first station in the greater Boston area. Back in 1921, WBZ was nowhere near Boston; it was located at the Westinghouse plant in East Springfield, Massachusetts,³ more than eighty miles away, and it did not open a Boston studio until early 1924. A timeline of key dates in AMRAD’s broadcasting history is shown in the accompanying sidebar (see next page).

The AMRAD station opened its studio facilities in late 1915, on the Tufts College (today Tufts University) campus at Medford Hillside, (see Fig. 1), about six miles from downtown Boston. According to *Radio Service Bulletins*, the

AMRAD TIMELINE: KEY DATES IN BROADCASTING

- Fall 1910:** Tufts freshmen Harold J. Power and Joseph Prentiss create the Tufts College Wireless Society.
- Fall 1911:** Tufts Wireless Society opens its first station with equipment donated by the Signal Corps.
- June 1914:** Harold Power and Joseph Prentiss graduate from Tufts College; they will become the founders of the American Radio and Research Corporation (AMRAD).
- June 1915:** Incorporation of AMRAD.
- August 1915:** Agreement signed between Harold Power and Tufts College for construction of AMRAD/Tufts shared facility.
- November 1915:** AMRAD's first research laboratory completed; first broadcast tower in operation.
- March 1916:** First documented broadcasts of voice and music at the AMRAD station.
- February 1917:** Call sign 1XE first appears in the *Radio Service Bulletin*.
- May 1918:** Eunice Randall is hired by AMRAD as a "draftslady"; she will become 1XE's first female announcer and one of the first in New England.
- August 1920:** New and expanded AMRAD plant is completed.
- September 1920:** 1XE is broadcasting sporadically; first documented mention of the AMRAD station's call letters post-war, in the "calls heard" section of *QST*.
- February 1921:** Call sign 1XE first appears after WWI in the *Radio Service Bulletin*.
- May 1921:** Station 1XE begins regular schedule of daily broadcasts.
- November 1921:** Eunice Randall gives her first radio bedtime story.
- December 1921:** Boston Mayor James Michael Curley gives his first political talk by radio; economist Roger Babson gives his first radio business talk.
- February 1922:** 1XE becomes WGI, per order of the Department of Commerce.
- April 1922:** Tufts College professors begin a series of educational courses by radio; noted black actor Charles S. Gilpin gives his first radio dramatic reading; WGI broadcasts its first commercials, but Radio Inspector orders the station to stop.
- January 1924:** "Big Brother" Bob Emery debuts popular children's show, the Big Brother Club.
- March 1925:** WGI changes its call letters to WARC.
- April 1925:** News reports announce AMRAD is going through bankruptcy proceedings.
- May 1925:** Without warning, the AMRAD station ceases to broadcast.
- December 1925:** Powel Crosley Jr. announces he has purchased AMRAD and WARC, says manufacturing of radios will continue; promises WARC will return to the air (it never does).
- 1930:** Crosley abandons plans to keep AMRAD factory going, shuts it down.



Fig. 1. The first AMRAD research laboratory, complete with a 300-foot radio tower, was built in 1915 on Medford Hillside, just north of the Tufts college buildings. (Miller, *Light on the Hill*, p. 393)

AMRAD station was first licensed as 1XE in December of 1916 or January of 1917.⁴ However, newspaper articles attest to the fact that, with or without a license, the AMRAD station began broadcasting voice and music as early as March 1916, and sporadically thereafter.⁵ And there is further evidence in newspaper archives that 1XE began a regular broadcast schedule by May of 1921.⁶

The AMRAD station never had opulent studios or a big promotional budget, and it rarely operated with more than 100 watts.⁷ Yet despite frequent financial problems, it managed to broadcast for nearly a decade, and during that time, it had many unique accomplishments. For example, the station hired Eunice Randall, one of radio's first female announcers,⁸ who also helped with engineering, read bedtime stories to young listeners, and was a licensed ham radio operator. It broadcast a morning exercise-by-radio program aimed at helping listeners to lose weight.⁹ It pioneered some of the earliest on-air adult education courses, featuring Tufts College professors.¹⁰ The station aired daily newscasts with reporters from a Boston newspaper,¹¹ which included the latest police reports of stolen automobiles.¹² In addition, the well-known economist Roger Babson hosted a weekly program in which he offered his perspectives on business.¹³ Station 1XE/WGI was home to the "Big Brother Club," the most popular children's show in town.¹⁴ The AMRAD station may also have been the first to run paid commercials, much to the consternation of the Federal Radio Inspector.¹⁵ Some of its performers, including Joe Rines, Bob

Emery, and Hum & Strum, went on to earn national recognition. Yet today, few people know that the AMRAD station ever existed.

Challenges in Researching Early Radio

There are several possible explanations for why other early commercial stations are much better known. One has to do with longevity; two of the earliest stations, KDKA in Pittsburgh and WWJ in Detroit, are still broadcasting, and thus still able to promote their claims to having been the first commercial station in continuous operation up to the present day. While 1XE/WGI was also broadcasting at that time and could join them in laying claim to being first,¹⁶ it went off the air in April 1925. And while many people whose careers began in Medford Hillside remembered the experience fondly even decades later,¹⁷ as the years passed, few were left to tell the AMRAD station's story. As might be expected, most radio fans were more interested in current stations, rather than remembering stations from the early 1920s that were long defunct.

The partial loss of the station's archives (including correspondence files) after its bankruptcy, and the change of ownership in mid-1925 also made it difficult to keep the 1XE/WGI story alive.¹⁸ The building that once housed the station was destroyed by a fire in 1972,¹⁹ and all that survives from the AMRAD station today are some individual pieces of correspondence between station management and several Tufts' deans and professors, as well as some exchanges (many related

to the state of the station's finances) between AMRAD's owner Harold J. Power and the president of Tufts (all preserved in the university's archives). Additionally, there are a few memos and letters that were saved by people who worked for 1XE/WGI. (I was fortunate to talk with several former "Amradians" before they died; their recollections were invaluable to my research.)

The loss of the original files, including station logs, is especially unfortunate since radio editors of that time were familiar with the information they contained. Lewis Whitcomb (better known as "Whit") was the radio editor for the *Boston Post* until he joined WEEI radio in late 1924. Writing for the Chamber of Commerce's journal *Current Affairs* in 1925, Whit claimed that these original files documented that the Medford station, then known as 1XE, began broadcasting before station KDKA did on November 2, 1920: "... [It] appears from records available at WGI that the Medford station was broadcasting regular programs at least a month before ... KDKA ..." ²⁰ The "Calls Heard" feature in the October 1920 issue of *QST* provides definitive proof that station 1XE was transmitting as early as September 1920. ²¹ Other reporters of the mid-1920s also alluded to the station's files; I only wish they had been saved.

And then, there is the problem of not knowing what kinds of programs were on the air in those early days. Since neither transcriptions nor audiotape had been invented, historians are unable to form any opinions by listening to what early broadcasts sounded like. I do have a

rare transcription that was made in 1937 for an anniversary celebration at Boston's WEEI; it contains a re-creation of a typical 1921 broadcast featuring Eunice Randall, one of 1XE/WGI's original announcers. While it is an interesting artifact, it would have been amazing to hear radio as it was being performed back in those early years. And although station program listings (printed in many newspapers during the 1920s) can be helpful, they do not reveal whether the program that was scheduled actually was aired, and if so, how it sounded. In later years, radio critics like Robert Landry of *Variety* or Howard Fitzpatrick of the *Boston Post* gave their assessment of the programs; but few radio critics existed in broadcasting's formative years. Further, some station listings in the newspapers only said "music" or "phonograph records," which doesn't reveal which selections the station was playing, or who announced the program. Thus, given the lack of actual broadcasts from 1919–1928 (some of the first transcriptions did not begin to appear, or get utilized by radio, until 1929), ²² and the lack of in-depth information about early programs, most of what we know about those early days mainly lives on in the writings of those who were there, as quoted in books, newspapers, and magazines, as well as whatever correspondence has survived.

Another challenge in researching the earliest stations is that much of what was covered in those formative years focused almost exclusively on the technology. This is understandable, since magazines such as *QST* (which debuted in 1915) and *Radio News* (which debuted as *Radio*

Amateur News in July 1919, as we see in Fig. 2) were founded by individual entrepreneurs or by companies that were either involved in amateur radio

or sold electrical supplies and equipment. If you read newspapers and magazines from this era, you will also notice there were many names for the new wireless



Fig. 2. Cover of the first issue of *Radio Amateur News*. (Courtesy of the American Radio History website)

apparatus—and even for radio broadcasting itself. Some newspapers, for example, tended to speak of the “wireless telephone.”²³ As the name indicated, it was envisioned as a new kind of telephone service, one that could transmit voice messages across the ocean without the need for wires. But by late 1919, a station that sent out the voice messages or music was called a “radiophone station,” and the apparatus that was associated with the ability to transmit voice and music in a broadcast was called a radiophone;²⁴ clearly, it did not refer to a person-to-person telephone conversation. Gradually, as more commercial stations came on the air in 1921, “radiophone” and “wireless phone” became the most commonly used terms when discussing a broadcasting station;²⁵ this would not change until the height of the “radio craze” in 1922–1923, when the word “radio” finally came into common use.

But by whatever name, there was not much coverage of the development of radio broadcasting in the period from 1910–1920. Oral histories, often compiled decades later, are certainly useful. But they can also be unreliable, given people’s tendency to get certain dates wrong or make themselves seem more important than they really might have been. The few newspapers that did report on wireless telephony experiments in that era generally did so by profiling the inventor or experimenter.²⁶ However, there was little ongoing coverage in the mass-appeal newspapers and magazines. Sometimes a newspaper would have a piece about a local amateur radio operator, or report on what the local college

wireless club was doing. But if you did not subscribe to a ham radio publication, or if you were not well versed in engineering, you would not have found very much about radio in the typical newspapers and magazines of that time.

Impact of the “Radio Craze”

During 1920 and 1921, only a few commercial stations were broadcasting; in February 1922, there were still no more than thirty-five.²⁷ But by mid-1922, the “radio craze” had begun. Suddenly, interest in “radiophone broadcasting” expanded dramatically, with hundreds of new stations going on the air—people of all ages were eager to have a set of their own.²⁸ Mentions of radio could be heard in popular songs, seen on greeting cards (see Fig. 3), and even President Warren G. Harding had a radio set installed at the White House.²⁹ While broadcasting was now reaching the masses—as opposed to being perceived as just a hobby for amateurs—it did not necessarily result in more coverage from the press. In fact, reactions were decidedly mixed. Some publications added a radio page (like the *Boston Herald*) or a radio column (like the *Boston Traveler* and the *Boston Globe*), but many others decided to completely ignore the radio craze. These editors regarded radio as competition, and they feared that writing about it would encourage people to stop buying their publications. While most magazines were weeklies or monthlies, the daily newspapers felt they were especially at a disadvantage. Although they published numerous editions throughout the day, there was still a lag time between when an event occurred



Fig. 3. This New Year's card from 1924 showed the excitement of "listening in" as the radio craze permeated American culture. (Author's collection)

and when the reporting reached the public. Radio did not have this problem; it was the first mass medium that could bring people to an event in real time. And so, in cities where newspaper editors believed radio was a threat to circulation, we find little information about the local stations that were on the air. Even the *Medford Mercury*, the newspaper nearest to where 1XE/WGI broadcast, was slow to report very much about what the station was doing.

Fortunately for researchers, there were more and more newspapers that

decided to report on radio. Some even hired a radio editor to talk about the announcers and entertainers (who were often one and the same). In that era of live radio, if a guest didn't show up, the announcer would fill the time somehow, often by singing or playing the piano.³⁰ One of the first newspapers to cover radio, the *Detroit News*, had an excellent reason for doing so. The *Detroit News* put its own radio station on the air in August 1920 using the amateur license 8MK, which later transitioned to WBL and then WWJ after receiving a broadcasting license. The *News* was the first newspaper to own a radio station, and anything that was on 8MK received thorough coverage, including a page-one report of election returns.³¹ Even

in cities where no newspapers owned a station, some newspaper editors saw an opportunity to make their readers happy. These editors understood that readers were fascinated by radio; and rather than ignoring it, some decided to embrace it, not only by writing about it, but also by providing a daily news broadcast, as the *Boston Traveler* did as early as April 1922 (see Fig. 4).³²

Modern researchers have been further aided by all the new magazines that emerged beginning in 1922. The "radio craze" resulted in numerous publications

that were aimed at radio listeners as well as experimenters who wanted to build their own equipment. A good example of a mass-appeal magazine was *Radio Digest*, which featured station listings as well as stories about key stations, profiles of some of the performers, and descriptions of unique programs.³³ Another interesting publication was *Radio in the Home*, which combined reporting on new and more stylish receiving sets with stories about the celebrities who enjoyed using them. While not every issue of these magazines has survived, many have been digitized (a great benefit for scholars of early broadcasting). One excellent repository for old radio magazines in digital form, including many technical publications and a wide variety of mass-appeal magazines, is the website AmericanRadioHistory.com.

Stations 1XE and WGI received a few mentions in these publications (their call signs appeared in program listings, and certain announcers or guests were the subject of occasional articles); the AMRAD station was also written about in some of the Boston newspapers).³⁴ But the station's accomplishments were quickly superseded by the stories of stations owned by bigger companies, especially stations that could afford to pay for big-name talent. In 1921 and 1922, when broadcasting was still new, the dominant style of reporting focused on stations that were the first to do something (such as broadcasting a World Series game or airing a talk by a famous celebrity). Also popular were stories about how amazed the listeners were to hear such wonderful programs. The reporters who covered

New in Radio
AN AFTERNOON
BROADCAST!
of NEWS daily
(Except Sunday)
Beginning April 17, 1922
 News Furnished by
THE BOSTON
TRAVELER
 will be broadcast every afternoon by The American Radio and Research Corporation (AMRAD Station WGI) of Medford Hills.
GET READY!
 This will be the first daytime broadcast in this part of the country as well as the first daytime news broadcast.
LISTEN IN
Every Day
at 2 P.M.—3 P.M.—4 P.M.
 Leadership in Radio news activities has been and will continue to be maintained by
The Boston Traveler

Fig. 4. Announcement of daily radio newscast. (*Boston Herald*, Mar. 31, 1922, p. 19)

radio commonly referred to it as a “marvel,” “a wonder,” and a “miracle.”³⁵ But as radio ceased to be a novelty, listeners increasingly developed favorite stations and favorite programs, and they wanted to know more about the performers and announcers they were hearing. They also began to expect consistent, high-quality programming. This trend was accelerated when the National Broadcasting

Company came along in 1926, followed soon after by the Columbia Broadcasting System. The existence of networks made it possible for famous performers and popular programs to be heard from coast to coast. Meanwhile, many small stations that had been popular in the early 1920s, 1XE and WGI among them, were unable to compete. These stations gradually faded from the public's memory.

As a media historian, I believe studying pioneering stations like 1XE and WGI can provide an important opportunity to explore how smaller radio stations, especially those not owned by deep-pocketed corporations, tried to find creative ways to stay on the air. After all, this was a time when "direct advertising" (what we now call "commercials") was frowned upon. Herbert Hoover, then the secretary of the Department of Commerce, believed broadcasting should be a public service, and as such, stations should not air any direct advertising at all.³⁶ This put smaller stations at a disadvantage as they tried to generate the revenue to pay the bills each month. What ultimately doomed AMRAD was its inability to remain financially solvent. It is worth noting that another researcher, the late Alan Douglas, has written eloquently about the business and manufacturing side of the American Radio and Research Corporation. He discussed in great detail the financial dilemmas faced by AMRAD, and the reasons for them.³⁷ But rather than researching the technology or the business aspects, my focus has always been on social history: how early radio affected (and changed)

people's lives, and how certain previously unknown local performers became household names, or even national celebrities. Station 1XE/WGI was the launching point for so many entertainers and announcers. Listeners were eager to learn more about the voices they heard, and the station issued promotional materials, usually post cards or pamphlets, to show the audience what the performers and announcers looked like. One example from 1923 appears in Fig. 5. Identifying who owned these radio voices and what their role was at the station is an essential part of the history of broadcasting.

The Man Who Founded 1XE/WGI

By all accounts, the idea for what became 1XE originated with Harold J. Power. Born in Everett, Massachusetts, in 1892, he fell in love with wireless telegraphy and amateur radio when he was a young boy, and by the time he was eleven, he had built a back yard shed where he could send and receive Morse code messages. He also built a rudimentary receiver, but it worked only sporadically; he would eagerly hurry home from school to try to improve its reliability.³⁸ After graduating from Everett High School in 1910, Power entered Tufts College. By then, he was already an experienced ham radio operator, one of the many boys and young men fascinated by wireless technology.³⁹ Power had also made progress in building receiving equipment, and he was considered enough of an expert on wireless telegraphy that Everett High School hired him to teach an evening school class on the subject. He later told an interviewer that at first, he taught

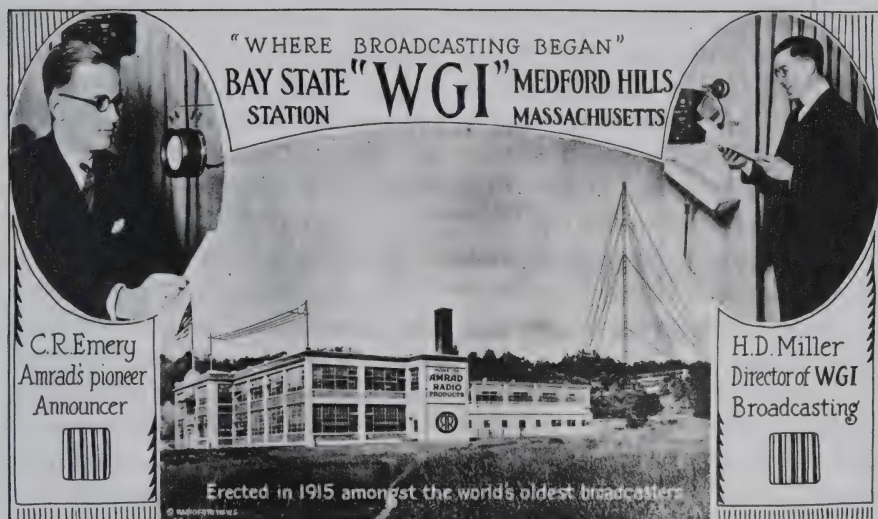


Fig. 5. A late 1923 promotional card, showing C. R. (Bob) Emery and H. D. (Herb) Miller of WGI, along with the station's claim it was "where broadcasting began." (Author's collection)

for free because the school was not sure there would be enough interest to sustain the course. But when it proved to be very popular (thirty students signed up immediately), he was officially hired as an evening school instructor, and the money he earned helped pay for his college education.⁴⁰

One of the students in that class was Guy R. Entwistle, who became Power's classroom assistant. Entwistle subsequently enrolled at Tufts, where he continued to work with Power while studying engineering. In 1914, while still a student, Entwistle joined the newly-founded Amateur Radio Relay League, and he went on to serve as the organization's New England Division Manager.⁴¹ After graduating from Tufts in 1918, he became the director of the Boston-based Massachusetts Radio and Telegraph School (later renamed the Massachusetts

Radio School).⁴² He remained there for more than four decades and was well known in the field of vocational education, training students for jobs in all aspects of broadcasting. In the early 1920s, he occasionally went on the air at 1XE/WGI to give talks about the latest trends in technology.

Lest this biographical sketch seem like a digression, Guy Entwistle is an important part of the 1XE story. For one thing, as the President of the Tufts Wireless Association, he was responsible for the operation of its amateur wireless station (1JJ), which occupied the same building as the AMRAD station when AMRAD made its first broadcasts in early 1916. And for another, he was able to tell that story to a mass audience. In mid-February 1921, he was hired as the amateur radio reporter for the *Boston Traveler* newspaper, where he wrote a column three

days a week, and in addition to reporting what local amateurs were doing, he also covered 1XE's programming. By 1922, he became the *Traveler's* radio editor, and he increasingly wrote about the area's commercial stations. But it was Entwistle's 1921 reporting that turned out to be so invaluable. He was an eyewitness to the growth of broadcasting in Boston as it transitioned from amateur experimenters to commercial broadcasting. And he was also one of the few reporters who personally knew the staff of 1XE/WGI. Interestingly, it was thanks to his radio column that I first encountered the name of Eunice Randall in a column about the positive reception she was receiving as an announcer for 1XE.⁴³ Wanting to know more about her led me to research broadcasting's women announcers and performers, and later, that led to a book—*Invisible Stars: A Social History of Women in American Broadcasting*, the second edition of which was published in 2014.

How AMRAD and 1XE Began

Encouraged by physics professor Henry G. Chase, Harold Power and fellow Tufts student Joseph A. Prentiss, who was also a fan of ham radio, co-founded the Tufts Wireless Association in 1911. Power told a reporter for the *Boston Post* that the association intended to conduct ongoing experiments in wireless telegraphy and to develop "a sending station with a radius of 100 to 200 miles that was capable of receiving messages from any distance." The new Tufts wireless station would be one of the best and most up-to-date in the country.⁴⁴ One thing I noticed when reading local newspaper

interviews with Power—he was not lacking in self-confidence. He wanted reporters, many of whom knew little about wireless technology, to see him as an expert, so that they would quote him when they needed explanations for current trends. And when quoted, he often used hyperbole, asserting that his latest technological innovation would be bigger than anything that had come before it. Reporters seemed happy to go along with this. In one article about the Tufts wireless station, the writer says that Power was "known as the pioneer wireless operator of New England."⁴⁵ In another article, the reporter noted that Power had just invented a device that would make messages audible, even if there were electrical interference during storms. The reporter helpfully agreed with Power that this new device was "the biggest invention in wireless telegraphy since Marconi's discovery."⁴⁶

While Power quickly mastered the art of self-promotion, it was also true that he had some very real accomplishments. For one, thanks in large part to his skill with the wireless, he was able to work for several of the most important business leaders of his day. In the summer of 1911, while still a college student, he served as the wireless operator on the *Nora*, the private yacht of wealthy business executive John Jacob Astor.⁴⁷ Tragically, Astor was one of the people who died the following year when the *Titanic* sank. Power remembered him as "one of the finest men . . . that I ever met."⁴⁸ Then, in the summer of 1913, Power served as the wireless operator on the *Corsair*, the private yacht of financier J. Pierpont

Morgan's son Jack (J. Pierpont Morgan, Jr.). This relationship would later prove helpful, as Jack Morgan, who was put in charge of his father's financial empire when the elder Morgan died, agreed to provide financing for Power's broadcasting and manufacturing venture.

Undoubtedly, one factor that influenced Morgan's decision was when Power gave him an impressive demonstration of wireless telephony. In mid-March 1916, Power transmitted his second experimental broadcast from AMRAD's studios at Medford Hillside. Power's first music broadcast had taken place at the beginning of March, and some local amateurs who were accustomed to Morse code, were surprised to hear music.⁴⁹ For this particular broadcast, Power had one person he wanted in the audience, and so he notified Morgan beforehand to invite him to listen in. Morgan was heading home from England on a ship and was about seventy-five miles south-east of Cape Cod Massachusetts, but as requested, he went into the ship's wireless room. To his surprise, he was able to hear a three-hour broadcast of voice and music—various phonograph recordings that included marches, opera, and popular vocals.⁵⁰ Power's stunt had the desired effect. He had already discussed his dream of performing important experiments with wireless technology, and now Morgan had heard for himself what wireless could do. Although few people knew it at the time, it was Morgan's money (by some accounts, \$350,000,⁵¹ and by others, as much as \$850,000 before all was said and done⁵²) that turned Power's vision into reality.

Several well-respected historians believe that AMRAD transmitted this broadcast under the special license 1XE. For example, Tufts' historian Russell E. Miller writes in his book *Light on the Hill*: "Radio communication was made on the Tufts campus on the evening of March 18, 1916, when AMRAD, working with the Wireless Society as Station 1XE, broadcast three hours of phonograph music picked up in an area of over 100 miles, and interspersed with the customary code of ship to shore messages."⁵³ However, Miller does not cite any authority supporting his assertion that the AMRAD station used the 1XE call sign in this broadcast. To the contrary, the *Boston Globe* reported a week later that the source of this broadcast had been "Classified as a Mystery," and a great effort went into determining that it was the AMRAD station. If AMRAD had been using call letters, the source of the transmission would have been no mystery. Supporting the postulate that 1XE had not been assigned to the AMRAD station at that time is *Radio Stations of the United States*, published by the Department of Commerce in July 1916,⁵⁴ which listed all the known radio station call signs circa the publication date. Conspicuous by its absence from the list of radio stations of the United States in this document is 1XE. However, it does list the Tufts Wireless Society station under the call sign 1JJ, with Guy R. Entwistle listed as the owner.⁵⁵

Harold Power graduated from Tufts in 1914 with a Bachelor of Science in Electrical Engineering.⁵⁶ By the summer of 1915, he and fellow grad Joseph

Prentiss had founded the American Radio and Research Corporation (soon to be known as AMRAD). Located on the Tufts campus, the company's building included a laboratory for scientific work and an adjacent room that could be used either for classes in wireless technology or to hold meetings of the Tufts Wireless Association. And a huge steel tower was also under construction, with plans for it to reach 304 feet.⁵⁷ Harold Power became the president of AMRAD, and he was soon featured in



Fig. 6. This photo of Harold J. Power was included in his profile that appeared in the *Boston Post*. (Sept. 25, 1915, p. 4)

several favorable profiles in the Boston newspapers (see Fig. 6). Most members of his team were Tufts graduates, current students, or family members (including his older brother John). Unfortunately, not long after the tower was completed it came right back down again. In late September, a severe storm with intense gusts of wind caused it to fall, nearly resulting in a train accident. The tower came to rest across the Boston and Maine Railroad tracks, and only quick action by the engineer stopped the train and prevented a catastrophe.⁵⁸ The people who lived nearby had been concerned about the huge wireless tower, and when it fell, they undoubtedly hoped it would not be rebuilt. But it was—and this time, more precautions were taken to secure it.⁵⁹ AMRAD was officially ready to embark upon manufacturing equipment and performing wireless experiments.

"Listening in" in 1921

Although its location was close to many of Tufts College buildings on the north side of College Hill, station 1XE was not a college station. Harold Power had obtained permission from the then-college president Hermon C. Bumpus to lease a plot of land and build the AMRAD laboratory and factory.⁶⁰ He successfully made the case that AMRAD's radio experiments would be of great practical benefit to Tufts students studying physics and engineering, as well as to the professors who were teaching these subjects. And during World War I, as historian Alan Douglas has pointed out, there was plenty of work. Manufacturing equipment for the military

became very lucrative for the new company, to the point where AMRAD had to hire more staff. By 1918, seventy-five people were working at the Medford Hillside factory.⁶¹

Ultimately, a new and larger plant was necessary, and it opened for business in the summer of 1920 (see Fig. 7).⁶² The war had required that manufacturing for the military take precedence over experiments with voice and music, and amateur stations were not allowed to broadcast until the war was over. By 1919, the war had ended, and radio experiments resumed. However, there is little contemporaneous information about events from that time period. From correspondence written by former AMRAD employees years later, they recall the occasional broadcast of phonograph

records or sports scores, and there was one time in late February 1919 when AMRAD installed a “wireless telephone” so that greetings to President Woodrow Wilson could be sent by Boston dignitaries as the ship he was on was approaching the harbor.⁶³ Unfortunately, we do not know if this experimental transmission was successful. An AMRAD timeline of historical achievements claims it occurred, but I have found no verification in newspapers or other documents.

In the period from 1919–1920, much of what 1XE seems to have transmitted was in Morse code, with the objective of sending messages to more and more distant locations. According to employee Eunice Randall (later Eunice Randall Thompson), it wasn’t until early 1921 that some actual (and regular) programs were



Fig. 7. Construction of a new AMRAD factory and research laboratory was completed circa September 1920; the 300-foot 1XE tower appears in the background. (Author’s collection)

Greater Boston's Pioneering Broadcast Stations 1XE and WGI

being broadcast. Eunice was in her late teens when she joined AMRAD in 1918. It wasn't something she had planned to do; she had come to Boston from her native Mattapoisett, about 70 miles from Boston, to attend art school. When she ran out of money and needed a job, she found one at a company that normally would not have hired her. Most of the men were overseas during WW I, and AMRAD was desperate for someone who knew how to make technical drawings and blueprints—even if that someone was female. Eunice turned out to be a capable draftsman (or a “draftslady,” as she wanted to be called), and when 1XE

went back on the air, she also turned out to be a capable announcer. In addition, she was an extremely versatile employee. She studied amateur radio and obtained her first-class license (her call letters were 1CDP, and later W1MPP), and she knew how to do basic studio repairs. She could also demonstrate AMRAD equipment at trade shows and conferences.⁶⁴ For example, we see her in Fig. 8 along with her AMRAD colleagues, Ken Thompson and Howard Tyzzer, at the New York Radio Show in March 1922. Eunice became well-known in greater Boston as the “Story Lady,” reading bedtime stories to children,⁶⁵—and thanks to



Fig. 8. Eunice Randall was often called upon to demonstrate AMRAD equipment at trade shows. This photo shows (l-r) Eunice, Ken Thompson, and Howard Tyzzer at the New York Amateur Radio Show March 7, 1922. (Author's collection)

how far AM signals carried, Eunice was soon receiving fan mail from listeners throughout the eastern United States.⁶⁶

Eunice became so popular that everyone wanted to listen to the "OW from 1XE," as she was called in newspapers. The phrase also appears in this very rare response postcard that AMRAD created for the 1921 Radio Show in Chicago (see Fig. 9). In ham radio, a male operator was jokingly called an "OM"—old man, an affectionate term derived from British slang. When a few women became ham radio operators, at first the term "OW"—old woman—was used; hence, Eunice was called the OW of 1XE. But in a culture where aging was perceived as something negative for women, who were even encouraged to lie about their age, it quickly became apparent that a better term was needed. By the 1930s, OW had been changed to YL—young lady.

In an era when more women were entering the workforce or attending college, it must have been inspiring for female listeners to learn about all of Eunice Randall's accomplishments in broadcasting. Radio reporters were also fascinated by the idea of a "lady announcer" (even in 1922, nearly all announcers were men). A number of articles were written about Eunice, and they often included photographs of her in the studio. A photograph of her broadcasting in the AMRAD studio appears in Fig. 10. There is some evidence that this photograph was staged for the cameras, but her many fans were just happy to see what she looked like. Her radio work certainly kept her busy; in addition to the bedtime stories and fixing studio equipment, sometimes she reported the news or read announcements of local civic events. At other times, she

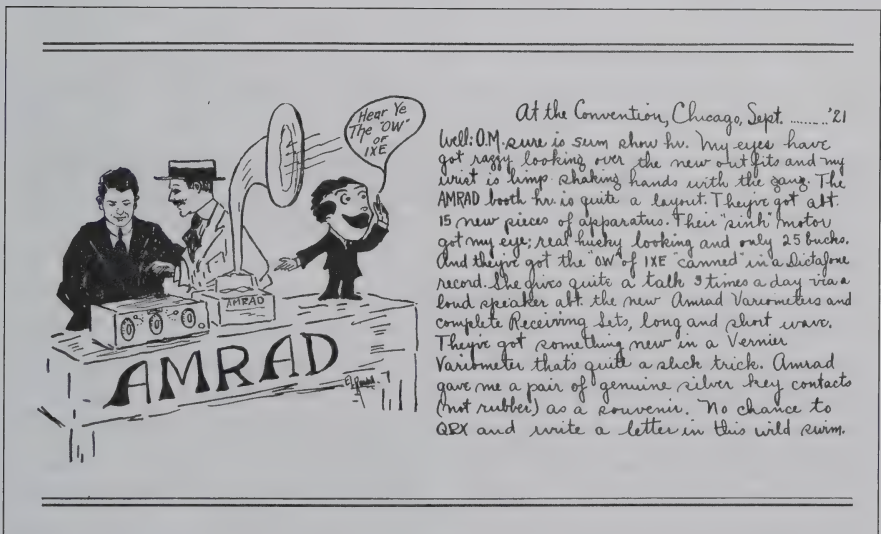


Fig. 9. A rare promotional card handed out at the Chicago Radio Show in September 1921. Note that Eunice is referred to as the "OW of 1XE." (Author's collection)



Fig. 10. Eunice Randall in the less-than-opulent 1XE studio reading a bedtime story in 1921. (Author's collection)

announced the police reports of stolen cars.⁶⁷ And when she had a day off, it was Howard Tyzzer, one of AMRAD's best engineers, who read them. But whoever read these reports, this feature got results. The newspapers noted that because the license plate numbers of stolen cars were broadcast, some eagle-eyed listeners saw the car in question and reported it to the police, who were then able to recover it.⁶⁸ In addition to fighting crime, Eunice could also perform. As mentioned earlier, when guests didn't show up, announcers had to fill the time, and she and one of her AMRAD colleagues sometimes sang duets.⁶⁹ Radio back then was still

primarily a volunteer activity. Eunice was paid for her work at AMRAD during the day, and she pitched in at night for no additional pay, just to assist in keeping 1XE on the air.⁷⁰

If you had "listened in" to the AMRAD station, or most of the other stations on the air in 1921, you would not have heard the types of formats we have today, or in some cases, any format at all. Stations back then had no official rules about consistency, and with few exceptions, they did not restrict themselves to just one genre of music. Station KYW, then located in Chicago, created an all-opera station in November of 1921, but

most stations preferred to broadcast a wide range of entertainment. What was on the air depended on which performers they were able to find. The programs were usually broadcast in fifteen-minute blocks of time, giving listeners plenty of variety. On 1XE, one sometimes might hear a concert consisting of phonograph records (bartered from a Boston record

shop in exchange for some promotional mentions), along with sports scores, inspirational messages from local clergy, an educational talk, Morse code practice for amateurs, and live performances by vocalists or bands. To my knowledge, only a couple of playlists from the AMRAD station's early days have survived, such as the one from 1921 reproduced in Fig. 11.

**WIRELESS TELEPHONE CONCERT, WEDNESDAY EVENING
Nov. 9, 1921**

Victor Records obtained through the courtesy of M. Steinert
& Sons, 35 Arch St., and 162 Boylston St., Boston, Mass.

- | | |
|---|---------|
| 1. President Harding March
United States Marine Band | 18768-A |
| 2. Nightingale and the Rose
Soprano Mabel Garrison | 64978 |
| 3. Humpty Dumpty
Comic Duet - Billy Murray-Ed Smalle | 18810-A |
| 4. Scherzo (van Goens)
Cello Victor Herbert | 64298 |
| 5. The Want of You
Tenor Edward Johnson | 64985 |
| 6. Hungarian Rhapsody, No. 2
Philadelphia Symphony Orchestra
Leopold Stokowski, Conductor | 74647 |
| 7. Virginian Judge, Part 1
Walter C. Kelly in Southern Court Scene
All characters which you hear in these two
numbers are impersonated by Walter Kelly alone | 45250-A |
| 8. Virginian Judge, Part 2 | 45250-B |
| 9. When It's Springtime in Virginia
Women's Quartet | 17437-B |
| 10. Tuck Me to Sleep in My Old 'Tudy Home
Fox Trot- Benson Orchestra of Chicago | 18889-A |
| 11. Drowsy Maggie- Medley of Reels
Irish Pipes, Patrick J. Touhey | 18639-A |
| 12. Love Sends a Little Gift of Roses
Baritone- Reinald Werrenrath | 64964 |

Fig. 11. Rare playlist of Victor phonograph records played by 1XE, November 9, 1921. (Author's collection)

By this time, there were some familiar voices making the announcements. While Eunice's was the most recognizable, 1XE was increasingly able to count on a group of regular announcers (a majority of whom, like Eunice, were AMRAD employees during the day), as well as a growing number of regular entertainers. Most of the performers back then were local; some came from area music schools and a few played at area clubs. One popular entertainer was E. Lewis Dunham, a Medford-based organist and choir director at Grace Episcopal Church. On air, he sometimes accompanied the vocalists, and at other times he gave solo organ recitals. Sometimes he also announced the programs. Dunham used the pseudonym "Uncle Eddie" when helping with children's programming; the remainder of the time, as was the custom back then, he used his initials, E.L.D. This custom came from amateur radio, and many announcers continued to use it well into 1925.⁷¹ For example, station announcer Herbert D. Miller, a Tufts College professor of English, was known on the air as H.D.M. It is also worth noting that the use of pseudonyms was common for the hosts of children's shows—Eunice Randall may have used her own name because reading stories to children was expected of a woman, but it was considered more unusual for a man in those days. Whatever the reason, the male announcers who read the bedtime stories on Eunice's day off or hosted a children's show of their own at 1XE/WGI, rarely used their real name. In addition to "Uncle Eddie," another popular announcer was known as "Uncle

David." His real name was David M. Cheney, and like his colleague Herb Miller, he was an English professor at Tufts when not on the air.⁷²

Also heard more often was a young vocalist named Claire Robins Emery (or Claire Robert Emery), who was becoming a listener favorite. He had been employed by Gilchrist's Department Store in Boston, but since he could sing, he became part of a vocal quartet the store used. At that time, many companies were building camaraderie through such activities as talent shows and outings, and it was common to read about employees who entertained at these events. The Gilchrist vocal group performed for 1XE, and soon Emery was in demand. He went on to become a popular announcer and singer on the station. A rare photo of him in those early days is reproduced in Fig. 12. Emery also spent some time as the program director of the station, and in early 1924 he debuted a children's show called the "Big Brother Club." Bob Emery became a beloved figure in Boston. His career in children's programming lasted nearly fifty years, first on radio, including network radio, and then on Boston television.⁷³

Because there was no money to pay for talent, the people who began to broadcast over 1XE were happy just to get some exposure. Although radio was still new and not everyone had a receiver yet, participating in this cutting edge technology was a great way to get some publicity. Despite the fact that there were no ratings services, that didn't stop the newspapers from guessing the size of the audience based on the number of



Fig. 12. Bob Emery and his ukulele at the WGI microphone in early 1924. (Author's collection)

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letters, telegrams, and phone calls the station received, and the size of the cities the contacts came from. By that metric, some broadcasts were heard by audiences estimated to be in the thousands. A good example was a performance in

early November by concert pianist Dai Buell. She not only played famous classical works but spoke to the listeners in between songs, explaining each piece. The photograph in Fig. 13 was taken in the special studio constructed for



Fig. 13. Concert pianist Dai Buell entertained the "invisible audience" in an AMRAD studio specially constructed for musical performers. (Author's collection)

performances such as hers. Response was very positive; one reporter estimated that about 25,000 people had heard the program. Station 1XE received post cards and long-distance telephone calls from as far away as Canada, Ohio, Pennsylvania and Virginia. There were also ships at sea that listened in.⁷⁴ And best of all for 1XE, the station received much favorable attention from the newspapers and magazines.

Another well-respected person who debuted on 1XE in 1921 was economist and statistician Roger W. Babson, founder of the Babson Institute (today Babson College) in 1919. He gave his first live talk on the AMRAD station on December 19, 1921. As with Dai Buell, his reasoning was probably that it was beneficial to have a potential audience of thousands of listeners (some of whom might never have had the opportunity to hear him), as opposed to renting out a hall and reaching a much smaller audience. In reporting on his talk, the *Boston Herald* said it was “the first business address ever given over the radiophone, and probably the largest audience which ever heard a business talk.”⁷⁵ In addition to becoming a source for hearing famous people, the station was also a source for “wireless music.” When people wanted to hold a dance but couldn’t afford to hire a band, they would set up a receiver and speakers and dance to the music they heard on the AMRAD station. Sometimes a local orchestra would come to the studio and play, giving listeners, wherever they might be, the opportunity to dance. In fairness, other stations, including KDKA in Pittsburgh, also found that

listeners enjoyed dancing by radio.⁷⁶ But 1XE/WGI took it one step further—by March 1922, the station was offering dancing lessons by radio, conducted by Prof. William H. O’Brien.⁷⁷

The Arrival of WGI

In 1921, 1XE had Boston radio all to itself. WBZ went on the air in mid-September from Springfield, but its signal did not reach Boston with any regularity. While a few distant stations could be heard in Boston on some evenings (most radio stations only broadcast during the evening hours at this time), people came to rely on their local station, 1XE. Although station personnel did their best to rise to the challenge, ongoing technical difficulties plagued the AMRAD station—equipment was constantly breaking, as Guy Entwistle frequently noted in his *Boston Traveler* columns. These problems meant broadcasts were often interrupted, much to the annoyance of the listeners. Fortunately, at that time, amateur operators were continuing their experiments with voice and music, and on occasions when 1XE couldn’t broadcast, local amateurs frequently stepped in. But this practice was finally forbidden in early 1922 by the Department of Commerce (precursor to the Federal Radio Commission), ostensibly because the broadcast band was becoming increasingly chaotic and there was too much interference from the amateur stations, which made it difficult for the commercial stations to be heard. Harold Power always disagreed with this decision, not just because he had a good relationship with many of the

local amateurs or because his company sold ham radio equipment, but because he failed to see any harm in letting amateurs broadcast. He also disagreed with the 1921 requirement that broadcast stations had to obtain a "limited commercial license," which he believed was unnecessary.

But despite how Power and some of the local amateurs felt about it, as of the first week in February 1922, amateur stations were no longer interchangeable with commercial stations, and could not broadcast "weather reports, market reports, music, concerts [or] speeches . . ." ⁷⁸ Each would have different and distinct functions, as well separate locations on the dial. As part of this government-mandated change, 1XE had to give up its experimental calls, and join the growing number of commercial stations at 360 meters (833 kHz). By February 8, 1922, 1XE became WGI. Interestingly, listeners were very worried; they had heard rumors that 1XE would be leaving the air, and they did not understand the station was simply transitioning to new call letters and a new dial position. The AMRAD station had to run frequent announcements on air, as well as in newspapers and magazines, letting everyone know 1XE, now WGI, was still broadcasting. ⁷⁹

Meanwhile, WGI was still greater Boston's only radio station, although two smaller stations, WAAJ and WFAU, came and went. In early April 1922, the AMRAD station earned national praise for creating a unique educational program in which Tufts College professors and other local educators offered

a weekly lecture series on such topics as "The Story of Engineering" given by Tufts' Department of Engineering Dean Gardner Chace Anthony, a big supporter of the AMRAD station; "The Story of Money" given by Dr. Harvey A. Wooster, head of the economics department; and "Changes in Europe" given by Professor Arthur Irving Andrews, head of the history department. Additional lectures were given on conservation, architecture, modern drama, athletics, music, and other topics. ⁸⁰ While this may not sound very exciting in our Internet era of "googling," in the early 1920s, few people were able to attend a university, and the opportunity to listen to well-known scholars was not widely available. This was one of the many ways radio changed people's lives. It brought news, sports, music, dramatic performances, comedy, religious services, and now educational courses, directly into the home, and anyone with a radio set, whether rich or poor, was able to benefit.

Radio also impacted greater Boston's minority community. While much of the programming reflected a segregated society (the announcers and most of the talent were white, as were the people who owned the stations), ⁸¹ some stations, 1XE/WGI among them, broadcast songs by black vocalists (gospel choirs were always popular). These stations also provided occasional in-studio performances by black entertainers. There were also dramatic performances; one of the earliest that we know about occurred at the AMRAD station and featured the famous black actor Charles S. Gilpin, then starring in the stage presentation

of *The Emperor Jones*. He came to the studios at Medford Hillside in April and performed some dramatic readings from the play.⁸² Black newspapers were especially pleased, saying this was the first time a minority actor had ever broadcast.⁸³ Four months later, a new and well-funded radio station, WNAC, owned by department store magnate John Shepard III, went on the air in Boston, and it also provided a performance by some famous black entertainers—Eubie Blake and Noble Sissle, along with Lottie Gee and other cast members of the hit play *Shuffle Along*.⁸⁴

Having an actual competitor, especially one with money to spend on the best equipment and salaries for top performers, would soon become a problem for the AMRAD station. But most fans of WGI were probably unaware that there were financial issues behind the scenes at the AMRAD plant. Trying to bring in some on-air revenue in a time when the Department of Commerce opposed the broadcasting of commercials meant that stations had to be creative. According to Eunice Randall's recollections, her bedtime stories program was briefly sponsored by *Little Folks* magazine, but this does not seem to have been an especially lucrative arrangement, and it did not attract the attention of Charles C. Kolster, the District 1 radio inspector. However, another attempt at sponsorship did.

In early April 1922, Harold Power sold some advertisements to a Boston auto dealer, Alvan T. Fuller of the Packard Motor Company. According to Power's recollections, he charged \$1.00

per minute, and if this worked out well, he planned to sell more sponsorships.⁸⁵ Unfortunately for Power, he never got the chance. Within several weeks of the first commercial, some anonymous person complained to the radio inspector. By late April 1922, radio inspector Charles Kolster had sent a cease-and-desist letter to AMRAD.⁸⁶ Many at AMRAD suspected the complaint had come from someone at AT&T, which was in the process of getting permission to experiment with "toll broadcasting" at WEAf in New York. Several months later, AT&T was able to conduct their experiment. But the fact that one company received permission to experiment with advertising didn't do AMRAD much good. Ideas about how to bring in money without incurring the wrath of the radio inspector continued to be discussed, but WGI continued to rely on AMRAD's manufacturing arm, which would soon prove to be problematic.

During 1922, WGI's programming became more consistent. Weekdays, there were regular weather forecasts, market reports, and programs for homemakers. Among the experts were Doris H. Goodwin of the Massachusetts Division of the Department of Agriculture, who gave helpful tips on how to spend money wisely when shopping for food, and Harriet E. Ainsworth of Filene's Department Store, an expert on clothing and trends in fashion. The station created the AMRAD Women's Club, with its blend of recipes, household tips, and guest speakers of interest to housewives. Since women had only recently been granted the right to vote, some speakers

discussed current events or politics. In the evenings, in addition to music concerts from choirs or glee clubs or local bands, sometimes there was a unique guest, such as in early September, when Amy Lowell read some of her poems. Few listeners had an opportunity to attend a poetry reading, so these broadcasts were always well received. Occasionally one might hear someone from the vaudeville stage like the popular singer and humorist Jimmy Gallagher, or someone like journalist and raconteur Joe Mitchell Chapple might stop by to give his observations on current issues.

And then, there was the exercise program, which began in September 1922. There was a fitness craze in the early 1920s, and many radio stations decided to offer health talks, along with exercises that people could perform at home. At WGI, health talks were a frequent feature, usually hosted by someone from the Red Cross or a local health department official. But this time, there was a before-breakfast program of setting-up exercises, hosted by Arthur E. Baird,⁸⁷ who at one time had attended Tufts. Baird worked at the Caines College of Physical Culture, and he claimed to be a fitness expert; he also claimed to be a Tufts graduate, but when I did some research in the college archives, I found this assertion was not true. However, the 1920s were a much less skeptical time, and it is doubtful that fans of his program saw him as anything other than an expert. Eventually, the exercise craze ended, and so did exercise-by-radio shows. Years later, Baird changed his name to Craig Earl and had a successful career on network radio as

"Professor Quiz." By then, he told everyone he had both a Ph.D. and a medical degree.⁸⁸ I have found no evidence that he had either.

The Beginning of the End for WGI

While WGI had many loyal fans, AMRAD's finances were worsening, and Jack Morgan was having grave doubts about investing more money into the company. Harold Power was known for having visionary ideas, but he was also a micro-manager, which often resulted in delays getting products to market while there was still demand for them. AMRAD engineers like Howard Tyzzer came up with some highly creative designs for equipment, but the company failed to reliably deliver the products on time, which caused endless problems; AMRAD also failed to effectively publicize them. For example, despite having receivers that could have been marketed to the general public, it wasn't until mid-April 1922 that promotional efforts aimed at the mass audience began in earnest, as evidenced by the brochure in Fig. 14. And even though AMRAD's products were good, it became increasingly difficult to compete with larger and better-organized companies like Westinghouse and RCA. By 1923, AMRAD was deeply in debt.⁸⁹

To make matters worse, the equipment failures that had plagued the station in its 1XE days persisted; but this became more of a problem in 1923 as new stations were going on the air in Boston and other nearby cities, and listeners now had other choices. As mentioned before, WNAC, the Shepard

WIRELESS TELEPHONE
for the
FAMILY

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1922

AMERICAN RADIO AND RESEARCH CORPORATION
Medford Hillside 57, Mass.

NEW PRICES EFFECTIVE APRIL 11, 1922

Amrad Crystal Receiver, No. 2575.	\$22.00
Stranded Aerial Wire, per 125 foot coil.	.75
Combination B-1 (less batteries and tube)	29.50
Adjustable Load Coil, No. 2962.	1.30
V. T. Detector, No. 2771.	16.50

Prices of Headset and Antenna Set, No. 2836 unchanged.

Fig. 14. A promotional brochure for AMRAD receivers from April 1922 illustrating that listening to radio was an ideal family activity. (Author's collection)

Stores station, went on the air in late July 1922. WGI and its team of volunteers were able to compete for a while, even though John Shepard III paid for famous stars to perform at his station. Fortunately, many of the entertainers who got their start at WGI remained loyal. While they performed for other stations, they still came back to Medford Hillside. And WGI still had its own unique (some might say “quirky”)

performers that audiences loved. One good example was Charles L. H. Wagner, known as the “radio poet.” A sign painter by profession, his other skill was an ability to create poetry on the spot—listeners sent in suggestions from current events, and he came up with a poem. He also composed humorous observations about life, and by popular demand, his radio poems ended up in a book. Wagner is pictured in Fig. 15 standing in front of



Fig. 15. Charles L. H. Wagner reading poetry to the audience at WGI circa 1924. (Author's collection)

a microphone at WGI reading poetry to his radio audience from his book of poetry, *Cradled Moons*, which was published in 1919. I had the opportunity to read it, and while he does not make one forget Shakespeare, his verses are a fascinating look at society in the early 1920s.

In early January 1924, the popular broadcaster by then known as “Big Brother” Bob Emery officially inaugurated the Big Brother Club. Aimed at boys and girls from 9–12 years old, it was an actual club, with dues (but not monetary dues), an official membership card, and the opportunity to attend special events sponsored by WGI. To join, all the prospective members had to pledge to do a good deed and write a letter to Big Brother each week. The program featured a combination of music, educational features, storytelling, comedy skits aimed at kids, and interviews with interesting guests. It also gave young performers a chance to be on the air. The Big

Brother Club was an immediate success, popular with parents and kids alike, and it brought WGI (and AMRAD) some much-needed positive attention.⁹⁰

In late February 1924, Westinghouse station WBZ, located in Springfield, Massachusetts, opened a Boston studio at the Hotel Brunswick, not far from the Theater District in Boston, a great place to find talented performers who might be willing to go on the radio. Having a Boston location, as well as an agreement with the *Boston Herald* and its sister newspaper the *Traveler* to provide news, gave the Westinghouse station a local presence. In an era when radio was live, this really mattered. WBZ (and its Boston station, then called WBZA) had greater access to Boston-based entertainers they could not have gotten in Springfield. WGI was now competing with two stations that had big budgets, beautiful studios, and the ability to compete for the biggest names. WGI soldiered on, and it continued to be known as a station that nurtured up-and-coming talent. That meant plenty of entertainers were still willing to broadcast from the AMRAD station, even if they didn't get paid much for doing so. Among the local performers winning many fans in 1924 were Bernie and his Bunch, a five-piece band led by piano player Bernard Eyges. The band's official publicity shot is reproduced in Fig. 16. Bernie wanted to go to law school, and his success as a bandleader helped him to pay for it.

Also doing well at WGI were a vocal duo who met in high school in Boston and began to perform—their real names were Max Zides and Tom Currier, but on



Fig. 16. "Bernie and his Bunch" in the WGI studios in early 1924. (Author's collection)

the air, they were better known as "Hum & Strum." The career they launched at WGI would continue for the next four decades on radio, and later on TV. Listeners also enjoyed hearing Joe Rines, who was another popular bandleader and recording artist. After leaving WGI and working for several other Boston stations, he was hired by NBC, and he later wrote advertising jingles.

No longer being the only station in town was taking its toll. Not only did WGI still have periodic technical problems, but now it began losing some of its on-air personalities. It also lost several of its best engineers, and when they left the station they were often hired by WNAC or WBZ for much more money. In late 1923, Eunice Randall was no longer on the air at WGI, although she continued to work at AMRAD for a while

longer. She too noticed that AMRAD's fortunes did not look bright.⁹¹ Eunice ultimately found a job in drafting at the New England Power Company, and she also remained active in amateur radio for many years, as we see in the early 1960s photo taken at her home in Maine (Fig. 17).

In mid-1924, an announcement was made by another large corporation, the Edison Electric Illuminating Company, that they planned to put a new station on the air in late September. The station had the call letters WEEI, and fans of the AMRAD station were undoubtedly surprised when Big Brother Bob Emery announced that he was leaving WGI to go to work there. Perhaps he sensed that WGI's finances were shaky, or perhaps he felt that being at a larger station like WEEI would take the Big Brother Club



Fig. 17. Eunice Randall (W1MPP), retired, married to Ken Thompson and living in Maine, still maintained an active involvement in amateur radio when this photo was taken in the early 1960s. (Author's collection)

to the next level. Whatever the reason for leaving, it was a huge loss for WGI, and one from which they never fully recovered. Bob Emery was one of the few well-known air personalities who had remained for so long, and now he too was leaving.

In March 1925, for reasons that have never been clear, WGI changed its call letters to WARC (**AMRAD** Radio Corporation). By now, most of its best-known announcers and performers were heard on other stations, and WARC was not even able to broadcast on a regular schedule any more. One day in late April, with no warning or explanation,

the **AMRAD** station simply vanished from the airwaves, and **AMRAD** itself went into bankruptcy. The station that was one of the radio pioneers, which used the slogans "where broadcasting began," and "**AMRAD**: the voice of the air" (implying that if you were listening to radio, you were probably listening to the **AMRAD** station) was gone from the dial, leaving listeners to wonder what had happened.

Station correspondence from Eunice Randall and Ken Thompson (the two had worked together at **AMRAD**, and many years later, they got married) indicated that Harold Power hoped to find

a buyer and put the station back on the air again, but it didn't happen. Eunice had also heard that John Shepard III of WNAC expressed an interest in buying the station, but Shepard wanted total control, and he would only agree to buy it if Power resigned. Power refused, and the deal fell through. Although Power continued to renew the license and hope for the best, at some point it seems that he resigned himself to the fact that the radio station would not return to the air.

As for the company he had founded, AMRAD went into bankruptcy, creditors fought over the company's assets, and Tufts reacquired the land.⁹² In late 1925, Power was able to sell what remained of those assets to Cincinnati-based equipment manufacturer and executive Powel Crosley. There was talk that Crosley might revive the radio station and continue to manufacture equipment under the AMRAD name.⁹³ Unfortunately, Crosley decided not to put WGI back on the air, and while the AMRAD name was used on equipment for a few more years, the manufacturing operation went out of business in 1930.⁹⁴ And as for Harold Power, he ultimately left Boston and started an engineering firm in Washington, D.C. In the summer of 1964, former members of AMRAD and 1XE/WGI held a reunion in Winchester, Massachusetts, at the home of James Jenks, who had been an engineer at the station. Harold Power was among the attendees, along with Eunice Randall Thompson, Bob Emery, and many others.⁹⁵

It would be easy to dismiss the AMRAD station as one of the many small stations that was beloved when

radio was still a novelty, but which lacked the consistent professionalism (and big-name talent) the networks could offer. For me, however, the story of 1XE/WGI is a fascinating look at radio's formative years: how a new station emerged, thrived for a little while, and then disappeared, still remembered by fans and former personnel years later, but ultimately forgotten. Despite the challenges of preserving the AMRAD story, I have persevered with my research for more than two decades, periodically finding new information to add to my understanding of who worked there and what the station meant to the audience. Keeping the story of 1XE/WGI alive is my way of saying thank you to the innovative and talented people who helped to create broadcasting in Boston.

Endnotes

1. "Huge Wireless Plant Going Up," *Boston Globe*, Sept. 25, 1915, p. 9. Also, Israel Klein, "Two Claim Parentage of Scheme," *Sun (Lowell, MA)*, Aug. 4, 1924, p. 11.
2. "E. Lewis Dunham Reviews Radio Career," *Boston Globe*, Sept. 25, 1927, p. 23.
3. "What's on the Air?," *Boston Globe*, Sept. 18, 1931, p. 41.
4. *Radio Service Bulletin*, Department of Commerce, No. 46, Feb. 1921.
5. This was not only a claim made by station management; it was also believed by local musicians and a few reporters who had been aware of 1XE/WGI since its inception. For example, William Arms Fisher, "The Radio and Music," *Music Supervisors' Journal* (Vol. 12, No. 3), Feb. 1926, p. 10.
6. Willard DeLue, "Those Amazing Years," *Boston Globe*, Mar. 15, 1950, p. 19.
7. "Amrad WGI," *Wireless Age*, Dec. 1923, p. 37.
8. William G. H. Finch, "Girl Becomes Famous as Radio Designer," *Newcastle (PA) News*, June 26, 1922, p. 7.

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9. "Calisthenics by Radio," *Jersey Journal* (Jersey City, NJ), Oct. 15, 1922, p. 6.
10. "Delivering a Lecture at Tufts by Radio," *Radio World*, Apr. 29, 1922, p. 13.
11. Advertisement for WGI, published on the Radio Page, *Boston Herald*, Apr. 2, 1922, p. D8.
12. Guy Entwistle, "Citizen Wireless Dots and Dashes," *Boston Traveler*, May 28, 1921, p. 10.
13. "By Radio Today," *Washington (DC) Evening Star*, Sept. 18, 1922, p. 17.
14. "Review of Last Night's Radio," *Boston Herald*, May 3, 1924, p. 6. Also, Joe Rines, quoted in endnote 10, reported that more than 40,000 "Big Brother Club" fans showed up for a station outing and a chance to meet Bob Emery.
15. Harold J. Power, interviewed by George H. Clark, Oct. 22, 1941. Documents from George H. Clark, Radioana Collection, Archives Center, National Museum of American History, Smithsonian Institution, Washington, D.C.
16. Israel Klein, "Two Claim Parentage of Scheme," *Lowell (MA) Sun*, August 4, 1924, p. 11.
17. For example, bandleader and songwriter Joe Rines, recalling more than two decades later the fan mail he and another WGI station personality, "Big Brother" Bob Emery, received, and the surprisingly large crowds that showed up for station events. Quoted by Jack Hellman, "Light and Airy," *Variety*, July 11, 1946, p. 8.
18. Alan Douglas, *Radio Manufacturers of the 1920's*, Vol. 1. (Sonoran Press, 1988) p. 40.
19. Margo Miller, "Fire Levels Hallmark of Radio Age," *Boston Globe*, Feb. 21, 1972, p. 11.
20. Lewis J. Whitcomb, "A Nine Year Old Marvel," *Current Affairs*, Mar. 16, 1925, p. 14.
21. "Calls Heard," *QST*, Vol. 4, No. 1, Oct. 1920, p. 49.
22. Ross Laird, "Brunswick and National Radio Advertising Co." From his book *Brunswick Records: A Discography of Recordings, 1916-1931*, (Greenwood Press, 2001) pp. 33-37.
23. "Tumulty Here Tonight for Wilson Reception," *Boston Herald*, Feb. 21, 1919, p. 6.
24. "Local Amateur Hears Carols by Wireless," *Ann Arbor (MI) News*, Dec. 24, 1919, p. 8. This article referred to how Christmas music was "sent broadcast" by a "radiophone" at a local university.
25. For example, "Wireless Phone Concert Heard from Kansas to the Cattle Ranges of Northwest States," *Denver Post*, Dec. 13, 1920, p. 11; and "Send Market News by Radiophone," *Riverside (CA) Daily Press*, May 19, 1921, p. 10.
26. For example, a conversation between two men actively involved in such experiments—Harold J. Power and Theodore N. Vail, "T. N. Vail Discusses Wireless Telephone," *Boston Post*, Oct. 10, 1915, p. 37.
27. "35 Radio Broadcasting Stations Now Active," *Charlotte Observer*, Mar. 3, 1922, p. 2.
28. "Plugging In Is Latest Craze to Hit Both Old and Young," *Springfield (MA) Sunday Republican*, Mar. 5, 1922, p. 1A.
29. "Radiophone for the White House," *Jersey Journal* (Jersey City, NJ), Feb. 9, 1922, p. 10.
30. Michele Hilmes, *Only Connect: A Cultural History of Broadcasting in the United States*, 4th edition. (Wadsworth/Cengage Learning, 2014) p. 48.
31. "The News Radiophone to Give Vote Results," *Detroit News*, Aug. 31, 1920, pp. 1–2.
32. "Traveler to Broadcast News Daily from WGI," *Boston Traveler*, Mar. 31, 1922, p. 1.
33. For example, the AMRAD station's first college courses by radio received praise from *Radio Digest*: "New Music of the Spheres, Wisdom of the Ages, Free to All by Air," *Radio Digest*, Apr. 22, 1922, p. 4.
34. Boston at this time had *nine* dailies, but only a few of them covered radio in the early 1920s.
35. For example, "Radio Program Is Miraculous," *Los Angeles Times*, Aug. 18, 1923, p. 7; or Bide Dudley, "Radiophone 8th Wonder of This Day," *San Francisco Chronicle*, Mar. 19, 1922, p. F1.
36. "Radio Congress," *Time*, Oct. 20, 1924, p. 20.
37. Alan Douglas, pp. 39–52.
38. "Has Solved Greatest Problem of the Wireless," *Boston Globe*, Jan. 16, 1916, p. 12.
39. For more on the phenomenon of "boy engineers," a 1992 volume called *Possible Dreams: Enthusiasm for Technology in America*, published by the Henry Ford Museum in Dearborn, Michigan, contains two informative essays that not only discuss the popularity of new media such as wireless telegraphy and telephony, but also examine how these new technologies became gendered spaces from which women and girls were excluded: Carroll Pursell's "The Long Summer of Boy Engineering," and Susan J. Douglas's "Audio Outlaws: Radio and Phonograph Enthusiasts."
40. John B. Chapple, "Radio Broadcasting to Millions," *The National Magazine*, Mar.–Apr. 1922, p. 494. Note that in this article, Power is referred to in extremely positive terms; one photo of him is captioned "The Man Behind

- Radio Broadcasting." This favorable perspective is not entirely surprising—the magazine was based in Boston and the editor, Joe Mitchell Chapple, was undoubtedly familiar with Power's work.
41. "With the Affiliated Clubs," *QST*, Sept. 1920, p. 39.
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 43. Guy R. Entwistle, "The O.W. at 1XE," *Boston Traveler*, May 17, 1920, p. 10.
 44. "Tufts College Students Operate Powerful Wireless Station," *Boston Post*, Jan. 28, 1912, p. 47.
 45. "Tufts New Wireless Station Will Be Opened Tomorrow," *Boston Herald*, Feb. 9, 1913, p. 15.
 46. "Tufts Man Muffles Lightning's Crash," *Boston Post*, Sept. 25, 1915, p. 4.
 47. "Expect Big Things of Tufts' New Wireless," *Boston Herald*, Jan. 2, 1916, p. C7.
 48. "The Observant Citizen," *Boston Post*, Apr. 18, 1912, p. 15.
 49. "Music Sent by Wireless," *Boston Globe*, Mar. 27, 1916, p. 8.
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 52. "Morgan Financed Start of AMRAD," *Christian Science Monitor*, Apr. 9, 1925, p. 14.
 53. Russell E. Miller, *Light on the Hill*, (Beacon Press, Boston, 1966) pp. 394–5.
 54. *Radio Stations of the United States*, Department of Commerce, (Government Printing Office, Washington, D.C., 1916).
 55. Ibid., pp. 78, 85.
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 57. "Huge Wireless Plant Going Up," *Boston Globe*, Sept. 25, 1915, p. 9.
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 59. "Expect Big Things of Tufts' New Wireless," p. C7.
 60. William B. Barrow Jr. "The Radio Plant on the Hill," *The Tufts College Graduate* (Vol. 18, Mar.-May 1920), p. 111.
 61. Alan Douglas, p. 39.
 62. "Flag Raising at Opening of New Medford Factory," *Boston Globe*, Aug. 1, 1920, p. 10.
 63. "Tumulty Here Tonight for Wilson Reception," p. 6.
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 65. "Eunice Randall is on Her Vacation," *Boston Herald*, July 9, 1922, p. D11.
 66. William G. H. Finch, "Girl Becomes Famous as Radio Designer," *Newcastle (PA) News*, June 26, 1922, p. 7.
 67. "She Sends Hundreds of Kiddies to Bed with Story," *New Bedford (MA) Sunday Standard*, Apr. 30, 1922, p. 35.
 68. "Newton Boy Recovered Stolen Auto by the Use of Wireless" *Boston Herald*, June 5, 1921, p. C12.
 69. Eunice Randall. "Hair Ribbon on a Radio Tower," *Yankee Magazine*, Apr. 1964, p. 112.
 70. Ibid.
 71. Erik Barnouw, *A Tower in Babel: A History of Broadcasting in the United States to 1933*, (Oxford University Press, 1968) p. 163.
 72. John E. Pember, "Behind the Scenes with the Talent in a Radio Studio," *Boston Herald*, Mar. 11, 1923, p. C12.
 73. "Big Brother Emery Retires After 47 Years of B'casting," *Variety*, 16 Jan. 1968, p. 12.
 74. "Miss Buell Plays for New England," *QST*, Dec. 1921, pp. 31–32.
 75. "Gives Business Talk by Radio," *Boston Herald*, Dec. 20, 1921, p. 8.
 76. "Dancing by Radio Music Contemplated," *Springfield (MA) Republican*, Mar. 11, 1921, p. 4.
 77. "In the Air Tonight," *Springfield (MA) Daily News*, Apr. 14, 1922, p. 14.
 78. "No Broadcasting for the Amateurs," *Jersey Journal* (Jersey City, NJ), Jan. 20, 1922, p. 15.
 79. For example, "Radiophone 1XE Now WGI," *Radio News*, Apr.–May 1922, pp. 967, 1010; "AMRAD Not Likely to Be Shut Down," *Jersey Journal* (Jersey City, NJ), Feb. 8, 1922, p. 6; and "Medford Hillside Station Expanding" *Boston Herald*, Feb. 19, 1922, p. D9. In each daily newspaper listing of station programs, the entry for WGI began "Station WGI (formerly 1XE)."
 - 80. "Lecture Courses to be Given over Radiophone," *Boston Post*, Mar. 28, 1922, p. 5.
 - 81. For more about this phenomenon, I recommend an informative essay by Derek Vaillant, "Sounds of Whiteness: Local Radio, Racial Formation, and Public Culture in Chicago, 1921–1935," *American Quarterly* (Vol. 54, No. 1) 2002, pp. 25–66.
 - 82. "Bits from the Emperor Jones Broadcasted," *Boston Herald*, Apr. 4, 1922, p. 11.

83. "First Actor to Broadcast via Radio," *Baltimore Afro-American*, Apr. 28, 1922, p. 11.
84. "Today's Radio Broadcasts," *Boston Herald*, Aug. 25, 1922, p. 11.
85. Harold J. Power, interviewed by George H. Clark, Oct. 22, 1941. Documents from George H. Clark *Radioana Collection*, Archives Center, National Museum of American History, Smithsonian Institution, Washington, D.C.
86. Information quoted from letters written by Charles C. Kolster to acting commissioner of the Dept. of Commerce, A. J. Tyrer, Apr. 18, 1922 and May 5, 1922, *Records of the Federal Communications Commission*, RG-173, BC-15, National Archives, Washington, D.C.
87. "Waking Exercise by Radio Latest Trick of WGI," *Atlanta Constitution*, 24 Sept. 1922, p. 8.
88. "Prof. Quiz of Radio Fame Has Enjoyed Varied Career," *Times-Advertiser Trenton (NJ)*, Jan. 14, 1951, Section 2: 1.
89. Alan Douglas, p. 40.
90. "Big Brother Club is Radio Feature," *Christian Science Monitor*, Jan. 8, 1924, p. 6.
91. Eunice Randall, "Hair Ribbon on a Radio Tower," *Yankee Magazine*, Apr. 1964, p. 112.
92. "Tufts Acquires Radio Properties," *Boston Herald*, Apr. 7, 1925, p. 7.
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Pictures by Radio for the Home

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The development of radio and television is not a story of some inventor's eureka moment, but rather a chain of small steps that progressed to the point of a service and products accepted by the public. Sometimes a small link in the chain and the work of an individual inventor is forgotten. The author uncovered a small, lost link in the chain between broadcast radio and television by finding a complete kit for a "Cooley Rayfoto System of Radio Pictures for the Home," in near mint condition. Its inventor, Austin G. Cooley, scarcely gets a mention in the literature nor does his system of radio pictures. This kit became the impetus for this article, which covers not only Cooley's system of still pictures for the home delivered by radio, but also similar systems of facsimile transmission made by others using the technique known at the time as "phototelegraphy." Systems developed by other early experiments are also summarized—those developed by N. S. Amstutz of Valparaiso, Indiana, circa 1891, Professor Arthur Korn of Berlin circa 1902, American inventor C. Francis Jenkins in the early 1920s, American inventor William Finch in the 1920s, and noted radio engineer and entrepreneur John V. L. Hogan circa 1937.

The Artifact is found

I was visiting the home of a collector to examine several items he had for sale. As we were finishing, he asked me to wait because he remembered one more item that might be of interest. After digging around a dusty closet, he pulled out an equally dusty box that was labeled with the curious name "Cooley Rayfoto System of Radio Pictures for the Home" (see Fig 1). It was a kit of parts to build this receiver. The kit had never been used and apparently had been opened only a few times. After taking it home, opening the box, and examining the components, I had more questions than I had components. When were these made? How was it used? What did you get to see? Who

was this man, Cooley? And most of all, why had I never even heard of this kit?

Some research revealed that the Cooley Rayfoto System of Radio Pictures was introduced to the radio public in a series of five articles in *Radio Broadcast* magazine. The first article appeared in the September 1927 issue, which was an introduction to the concept of still images being broadcast to home receivers.¹ In the second article, published in October 1927, "Now—You Can Receive Radio Pictures!," the director of the Radio Broadcast Laboratory, Keith Henney, explains how the Cooley System works and how an experimenter can build one for less than \$100.² In the November 1927 and December 1927



Fig. 1. Cooley Rayfoto Kit, like new in the box. (Author's collection)

issues,³ Cooley takes over writing the articles, and he tells the readers more about how the system works and how to build a Rayfoto System from the kit. Finally, in the January 1928 issue, author Edgar H. Felix goes on to tell owners how to optimize the operation and enjoy their Rayfoto receiver.⁴ The *Radio Broadcast* articles herald the Rayfoto System as a great advance in the art of pictures by radio. This raises two questions—what was the state of the art of radio pictures in 1928, and what came before this development by Mr. Cooley?

Early Transmission of Pictures by Wire and Radio

There is a long history of inventors attempting, with some success, to transmit images, first by wire and later by radio. The most basic plans utilized the telegraph lines to send a coded image. The sender would work from an agreed

code to break down the image into small pieces, decide on a code to describe that small piece, send that to the receiver, and move on to the next piece of the picture. The person at the receiver would then decode each piece and finally assemble an image. Inventors went to work to improve this tedious, impractical system with an electrical device. This electrical process would have to include converting an image to an electric signal, sending the signal to another location, and reassembling the image. This work was known by a few different names, but an early title for images sent by wire is “phototelegraphy.” The earliest references are for a method patented in 1842 by an English physicist named Alexander Bain.⁵ A conceptual drawing for Bain’s facsimile communication system from this early date is reproduced in Fig 2. Although a working system was never constructed, Bain’s proposed method

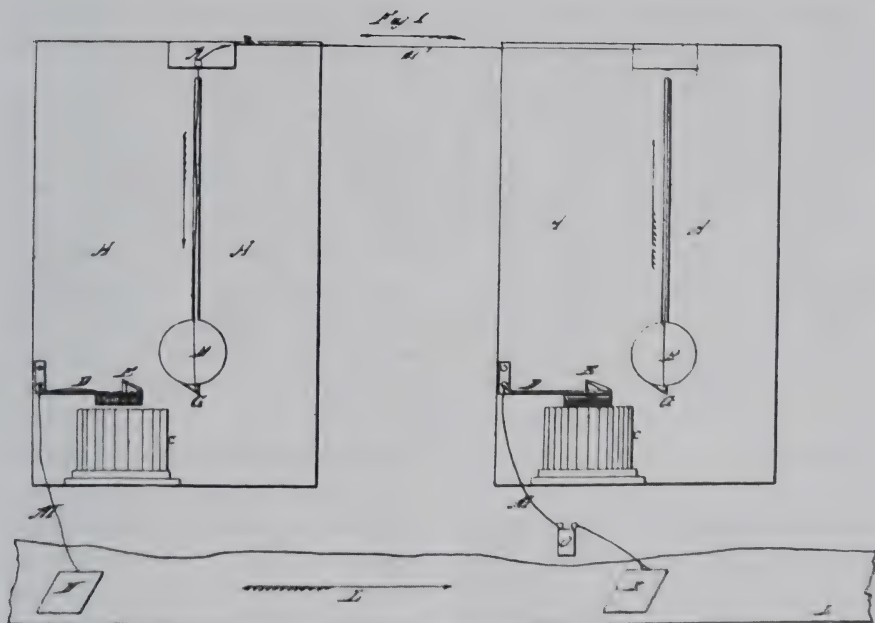


Fig. 2. Alexander Bain system patented in 1842. (*Radio Facsimile*, Vol. 1, 1938, p. 2)

was as follows: An image was painted on tinfoil using a nonconductive paint. An electrical contact was moved over the image and produced an electrical signal proportional to the conductivity at an individual point in the image. At the receiver, the signal was sent to a printer, where the current would discolor a chemically treated paper over the tinfoil. The last component was to synchronize the transmitter and receiver. This was accomplished by a signal line to synchronize a pendulum at the transmitter that controlled contact motion with a pendulum at the receiver controlling the printer motion. Many systems were later put into practice, some for experimental purposes and some to provide a commercial service. A few of the most significant systems under development

at the time are described next to provide an understanding of the concepts.

A system devised by N. S. Amstutz of Valparaiso, Indiana, was demonstrated in May of 1891. His clever plan is shown in a simplified diagram of Fig. 3. The first step in this process required that the

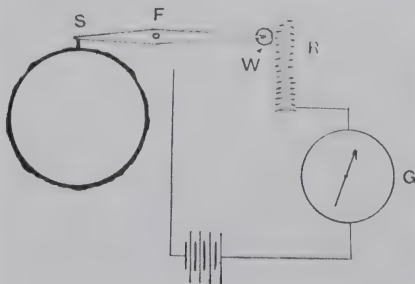


Fig. 3. Simplified diagram of Amstutz and Belin systems. (T. Thorne Baker, *Wireless Pictures and Television*, p. 100)

Pictures by Radio for the Home

image to be transmitted be produced as a relief photograph. There was technology at the time to produce such an image using a gelatin-like substance. The image was placed on a cylinder that advanced on a lead screw turned by a motor. Referring to Fig 3, the roller S appearing in the diagram traveled over the highs and lows in the image, and this motion was transferred by the arm F that moves the roller W. This roller varied the current passing through rheostat R that was sent by wire to a receiver. The receiver would print on a similar cylinder using a chemically treated paper that varied the print intensity in proportion to the current applied.⁶ This method was also used by Edouard Belin,⁷ who improved the process yielding impressive images

such as Fig. 4. His device shown in Fig. 5 was called the Belinograph, also known as the Telestereograph.

“Professor Korn’s Compensated Selenium System” is not the name of some quack medical product but rather a clever picture system developed by Arthur Korn in Germany. He produced a number of devices over several years and offered a commercial wired transmission service between cities, including Paris and London. One of his later systems, characterized by the schematic in Fig. 6, made use of the discovery that selenium has electrical properties that change in response to light. Although selenium devices were crude at the time, Korn devised a system using two closely-matched selenium cells, one at the transmitter and a second at



Fig. 4. Sample image from the Belin system. (T. Thorne Baker, *Wireless Pictures and Television*, p. 111)

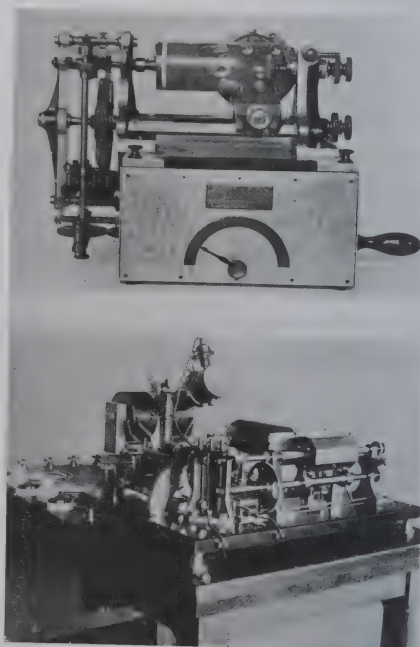


Fig. 5. Belin receiver (top) and transmitter (bottom). (C. Francis Jenkins, *Vision by Radio*, p. 82)

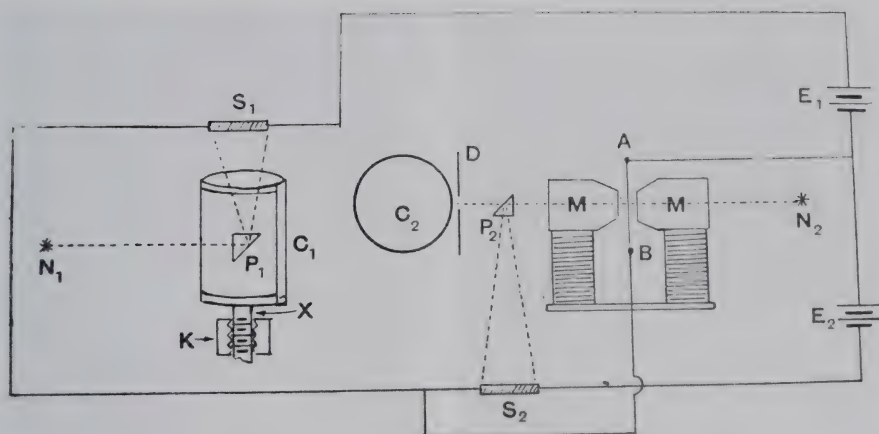
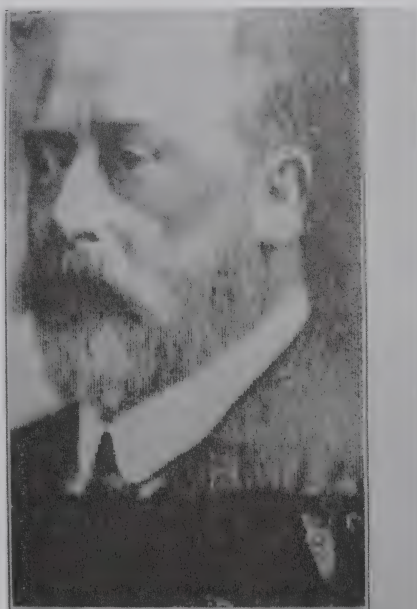


Fig. 6. Simplified diagram of the Korn system. (T. Thorne Baker, *Wireless Pictures and Television*, p.72)

the receiver. His circuit used the second cell to cut off and thus sharpen the pulse from the transmitter.⁸ This resulted in a sharper printed image, such as the one shown in Fig. 7. Professor Korn can be seen in Fig. 8 on the telephone in 1907 performing what may be called “manual synchronization,” and we can imagine him shouting to his associate, “hit start NOW.”

American inventor C. Francis Jenkins was already well-known for his inventions in motion pictures when he began work on picture transmission and later on mechanical television. Jenkins’s system utilized his own inventions, one called the Prismatic Disc and another an electrically powered tuning fork. The Prismatic Disc, shown in Fig. 9, was an optical device used to bend the light coming from the projected image that was to be transmitted. By grinding the outer ring of a glass disc at a gradually changing angle, light passing through would be bent. As the disc rotated, the angle of the light bending would shift



King Edward VII. The first photograph wired from Paris to London, November 7th, 1907.

Fig. 7. Sample image of King Edward VII from the Korn system in 1907. (T. Thorne Baker, *Wireless Pictures and Television*, p. 82)

so that the light would scan back and forth. He used a system of four of these

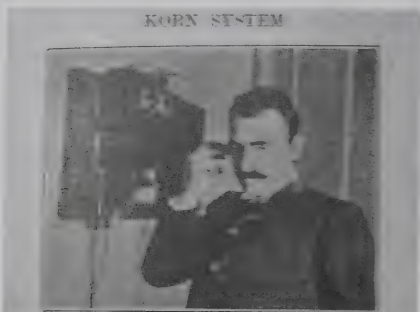


FIG. 39. Professor Korn at the telephone, when awaiting the first picture in Paris in 1907.



FIG. 41.— One of the first photographs wired by Korn's compensated selenium machines.

Fig. 8. Image of Professor Korn (top) and a sample image from his system (bottom). (T. Thorne Baker, *Wireless Pictures and Television*, p. 81)

discs, which allowed him to fully scan an image in both the vertical and horizontal directions. The transparency image to be scanned was projected onto the center of the four rotating discs. The set of discs then shifted the image vertically and horizontally over the aperture to a photocell. The motor spinning the discs was controlled by a Jenkins electric tuning fork.⁹

On the receiving side, a light source modulated by the received signal was passed through four identical Prismatic Discs rotated by a synchronized motor controlled by another Jenkins tuning fork. The image was then passed over a photographic plate that was photographically developed for the final picture. From 1922 onward, Jenkins was able to demonstrate better and better images, such as the one shown in Fig. 10, but it appears that he never went beyond the experimental stages. He also developed a system for sending radio movies, but

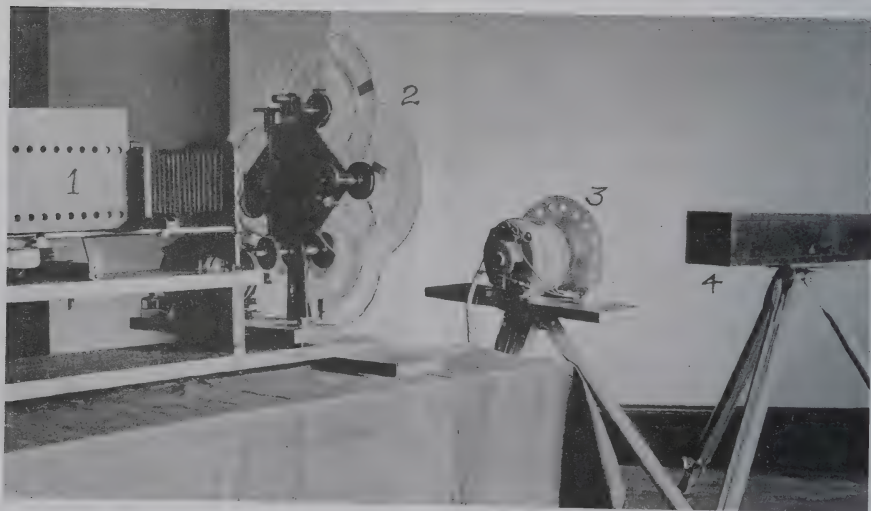


Fig. 9. Jenkins prismatic lens transmitter. (C. Francis Jenkins, *Vision by Radio*, p. 94)



Fig. 10. Sample image from Jenkins system. (C. Francis Jenkins, *Vision by Radio*, p. 19)

within a few years he turned his attention to mechanical television.¹⁰

In 1924, both RCA and American Telephone and Telegraph (AT&T) gave impressive demonstrations of the results of their research. The AT&T system was designed to send pictures over their telephone lines. The picture to be transmitted was placed on a transparent cylinder and an intense light passed through the picture onto a photocell. The receiver used a similar cylinder, and a focused and modulated light exposed a photographic film. A separate synchronizing signal advanced both cylinders. Two lines were needed, one for sync and one for the signal. In 1924, a picture was sent from Cleveland, Ohio, to New York. Although the picture was impressive, for example see Fig. 11, the transmission required use of the two lines for



Fig. 11. AT&T demonstration image from a 1924 test. (C. Francis Jenkins, *Vision by Radio*, p. 84)

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44 minutes.¹¹ The financial return for a picture service over long distance lines was deemed insufficient when compared to the return for long distance telephone and telegraph service.

In 1924, RCA gave a different type of demonstration. Engineers transmitted a photo like the one shown in Fig. 12 from New York to London, and London sent the same picture, now called a PhotoRadioGram, back to RCA in New York. The research team at RCA, led at the time by engineer Richard H. Ranger, was working toward the establishment of a commercial service to send pictures and documents for newspapers and businesses. RCA chairman Owen D. Young encouraged this research, telling his engineers he was tired of seeing

rooms full of people copying code to be typed as radiograms when they should be able to transmit entire pages of printed messages.¹²

The Cooley System

The young inventor Austin G. Cooley, pictured in Fig. 13, developed the Rayfoto system that was introduced to the radio public in the October 1927 issue of *Radio Broadcast*. The idea for this system of transmitting images came to him while he was an engineering student at MIT. Apparently, he became so driven to take his invention from conception to reality that he had no time left for his required studies, and he soon left MIT. Soon after he was introduced in the *Radio Broadcast* article in October



Fig. 12. First transatlantic Photoradiogram by RCA in 1924. (*Radio Facsimile*, Vol. 1, 1938, p. 18)



© Bachrach

AUSTIN G. COOLEY

Fig. 13. Photograph of Austin G. Cooley. (Rayfoto Owner's Manual, p. 3)

Fig. 14. Cover for a sales brochure listing parts and prices for Rayfoto image reproduction equipment. (<http://www.earlytelevision.org/pdf/rayphoto.pdf>)



1927, he became a staff member at the *Radio Broadcast Laboratory*. About this time, Cooley formed the Radiovision Corporation in New York to produce a kits of parts to help radio fans build receivers of their own (see Fig 14).

Who Would Build This...and Why

In the early 1920s, most of the broadcast radios were “homebrew” sets. Some were built from kits and others from published plans. The most avid home experimenters came up with their own plans for the best set. By the late 1920s, the large majority of sets being sold were factory made. The talented experimenter was always looking for the next project to astound friends and family. In *Radio Broadcast* magazine articles, authors would often state that after receiving their first radio picture, they got a much bigger “kick” over telling their friends they received pictures than telling them they received a west coast station the night before.¹³

Also, there was the lure of the promotional material such as the fight scene shown in Fig. 15. Imagine sitting back and getting a picture of a prizefight to

look at while you listened to the next round. This new technology was certainly the next best thing to being there. Sample images such as the one of the young lady reproduced in Fig. 16 were supplied in the manual.

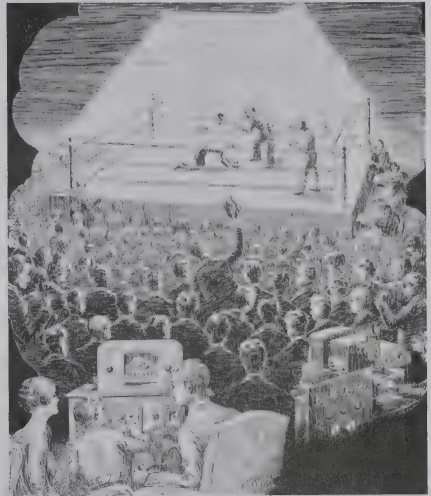


Fig. 15. Rayfoto promo sketch. (Rayfoto Owner's Manual, frontspiece)



Fig. 16. Cooley Rayfoto sample image. (*Radio Broadcast Magazine*, Vol. XII, No. 2 Dec. 1927, p. 114)

Building the Kit

Cooley expected that competent experimenters would be purchasing the kit shown in Fig. 17. With that in mind, and to keep costs low, he supplied only the major components that the builder would not have around his shop or could not purchase at his local radio supply store, for example, the parts shown in Fig. 18. He also made the assumption that the builder would use his or her home radio to listen to the program and would switch the speaker leads to the picture receiver when the picture broadcast started. Cooley also presented the option of building a cabinet with a spring-wound phonograph motor to turn the printer cylinder of the receiver or to use a coupler to turn the cylinder with

a Victrola turntable spindle, as shown in Fig. 19.

Construction of the electronic part of the receiver is straightforward and was certainly within the capabilities of the radio builder of the day. Blueprints were supplied for a front panel layout and a component layout. Cooley's Precision Printer is the major component of the kit. It includes the cylinder for mounting the photographic paper and gearing to match a motor. A coupler was also provided to attach the printer to a Victrola. The kit builder also received the Corona Coil, which was a Tesla Coil that would produce a high-frequency, high-voltage discharge, and a Corona Indicator, which consisted of a small glass chamber with two metal rods spaced to produce a



Fig. 17. Open Rayfoto kit. (Author's collection)

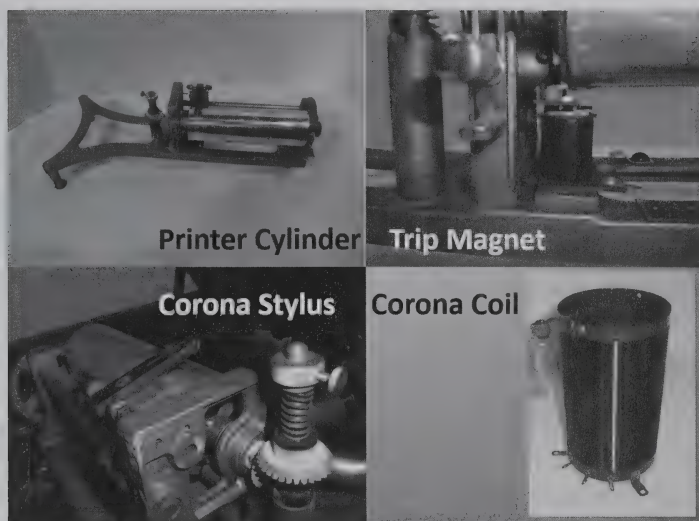


Fig. 18. (Left) Major components in the Rayfoto kit. (Author's collection)

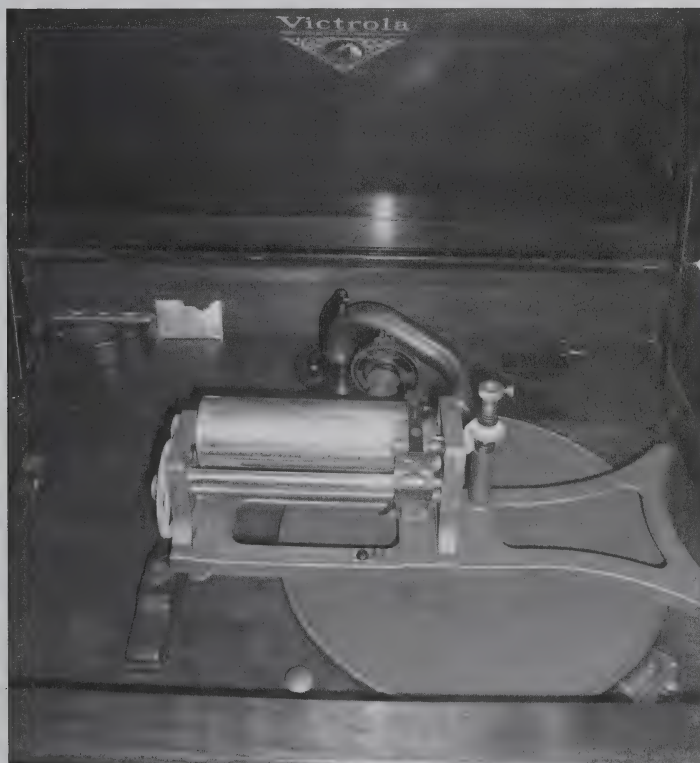


Fig. 19. (Below) Printer installed on a Victrola. (Author's collection)



Fig. 20. Rayfoto at WOR radio station. (*Radio Broadcast*, Vol. XII, Jan. 1928, p. 215)

corona. This allowed the operator to visually confirm the proper corona setting. A modulation transformer of Cooley's own design was included to provide the best operation, and a sensitive relay was also supplied; this released the trip magnet that released the cylinder to make each succeeding revolution. The finished kit shown in Fig. 20 resembled a tabletop radio but with the additional printer and batteries.

How it Works

The article in the November 1927 issue of *Radio Broadcast* together with the owner's manual gives a clear explanation of

how the Cooley system works. A drawing (Fig. 21) shows the components in the transmitter. A photograph is attached to a cylinder, and the cylinder is advanced on a lead screw. Each turn of the screw by the motor advances the cylinder by $1/80$ of an inch. Therefore, a picture five inches long would be scanned by 400 lines. As shown in the drawing, a chopper disc is rotated on the motor shaft. An intense beam of light is passed through the perforated disc. The disc is designed to chop the steady light source into 120 pulses per linear inch of scanning. The picture to be transmitted is four inches wide plus one inch of white paper. In

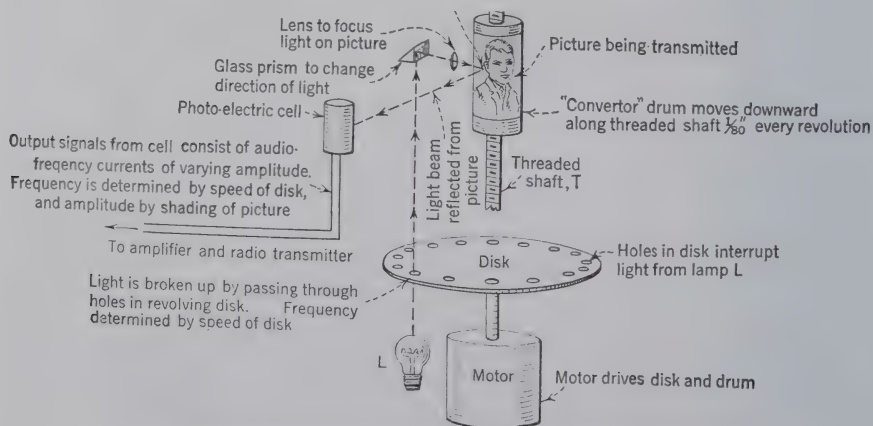


Fig. 21. Simplified diagram of the Cooley Rayfoto transmitter. (Rayfoto Owner's Manual, p. 4)

this way, the light is chopped into 480 flashes of light per line of the image. The white segment is used to provide time for a synchronizing pulse for each line of the image. The variations of light intensity reflected from the photograph are picked up by the photocell. The synchronizing pulse is a 1500 Hz note, and the picture signal is an 800 Hz note, amplitude modulated by an amplifier connected to the photocell (see Fig. 22). A modulation of 100% is black, and a modulation of 0% is white. This

scheme creates an amplitude-modulated signal that includes the 25-millisecond synchronizing pulse, with the output signal level designed to match the typical microphone level at the transmitter (Fig. 23).

The Rayfoto Picture Receiver shown in Fig. 24 is also described in the article. The basic functions are shown in the block diagram of Fig. 25. The outputs of the Rayfoto electronics connect to a printing cylinder. One output line connects to a trip magnet that is located under the

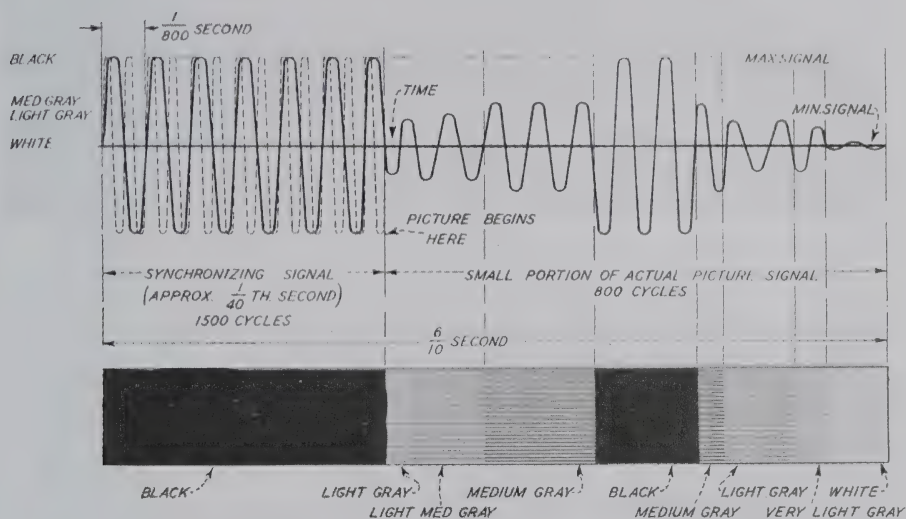


Fig. 22. Diagram of Cooley Rayfoto signal processing. (Rayfoto Owner's Manual, p. 5)

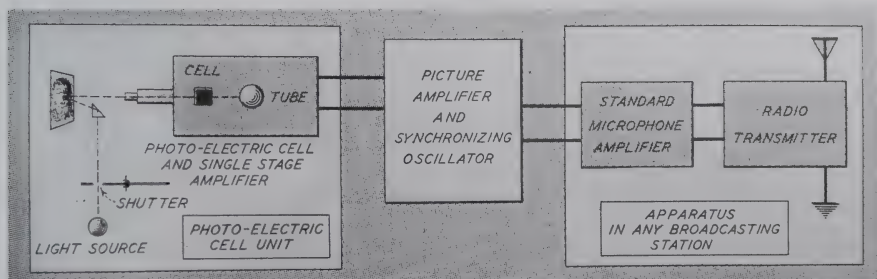


Fig. 23. Block diagram Rayfoto transmitter. (Rayfoto Owner's Manual, p. 4)

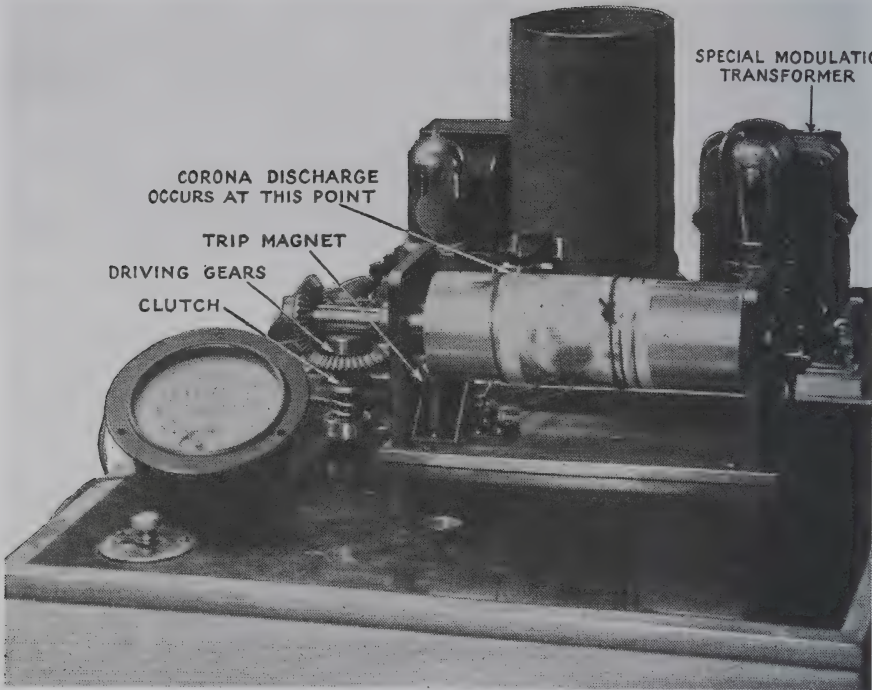


Fig. 24. Component layout of a Rayfoto receiver. (*Radio Broadcast*, Vol. XI, Oct 1927, p. 343)

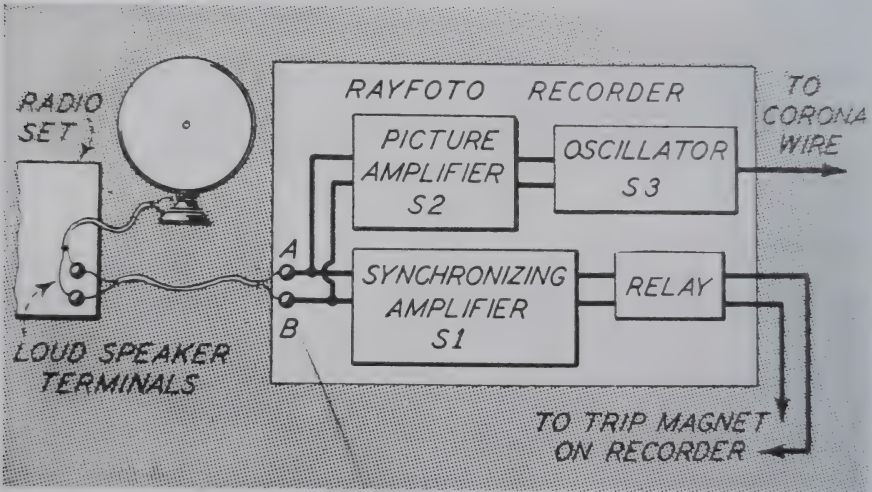


Fig. 25. Block Diagram Rayfoto receiver, (Rayfoto Owner's Manual, p. 6)

cylinder. A motor drive is connected to the cylinder that is held still by a mechanical catch. When the synchronizing signal energizes the trip magnet, the catch is released to allow the cylinder to make

one turn. Photographic paper is placed on the printer cylinder and the corona wire is attached from the electronics. The high-frequency corona from the receiver is wired to a corona stylus. This device is wired to a corona stylus. This device is similar to the steel stylus in a Victrola shown in Fig. 26, and it is positioned just above the paper. The stylus is then advanced on a lead screw of similar design to the screw in the transmitter. As the cylinder turns and advances, the corona exposes the paper in proportion to the incoming picture signal.

The schematic diagram of Fig 27 shows a three-tube circuit, each tube having the purpose shown in the diagram—picture amplifier, oscillator, and synchronizing circuit. The picture amplifier raises the input signal sufficiently to

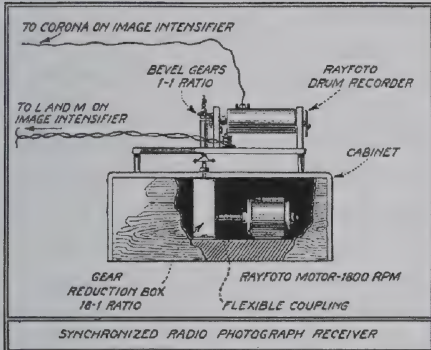


Fig. 26. Sketch of Rayfoto printer. (Rayfoto Owner's Manual, p. 15)

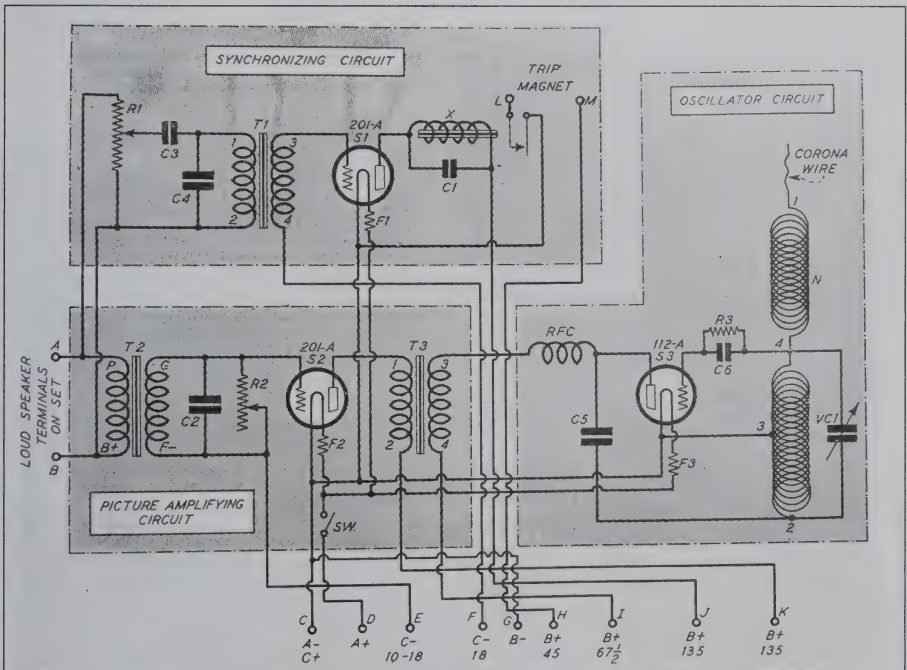


Fig. 27. Schematic diagram of Rayfoto receiver. (Rayfoto Owner's Manual, p. 10)

drive the modulation transformer. The oscillator tube generates a high-frequency signal that is modulated by the picture amplifier and drives the primary of the Corona Generator Coil. The synchronizing circuit, through the variable resistor R1, allows adjustment of the signal level and passage of the 1500 Hz synchronizing signal for each line. The triode S1 drives the relay X in the plate circuit, which enables the trip magnet at the cylinder. R1 can be adjusted to prevent false trips or missed synchronizing pulses.

The function of each synchronizing pulse is to open the trip magnet so the cylinder is released to start a line and the corona stylus exposes the photographic paper at intensities equal to the bright and dark areas of the scanned photographs. At the end of each line, the

cylinder is held up waiting for the next synchronizing pulse to start the process again. This will happen 400 times to produce a 4 by 5 inch image of arguably acceptable quality (see Fig. 28).

Cooley Rayfoto is "On the Air"

Having broadcasters interested in providing programming that included a picture transmission was as important to the success of the Cooley System as it was to have a large number households purchase receivers. As the number of receiver purchases increased, so did the number of broadcasters who wanted to be part of what they hoped would be the next craze. One of the first broadcasters was WMCA in New York. Their weekly program featuring the "Radio Visionaires" would begin by sending their audience a picture of that night's performance, such as the one shown in Fig. 29. The picture would enhance the radio fan's enjoyment as they listened to the rest of the program. A list of Rayfoto broadcasters is shown in Table 1.¹⁴ The



This likeness of Governor Alfred E. Smith would be considered a good average Rayfoto production.

Fig. 28. Rayfoto image of New York Governor Alfred E. Smith. (Rayfoto Owner's Manual, p. 17)

Program Prospects for Radiovision



Cast of the "Radiovisionaires," first Rayfoto picture broadcast group. They are at Station WMCA, every Wednesday night.

Fig. 29. Station WMCA's "Radiovisionaires." (Rayfoto Owner's Manual, p. 22)

Table 1. Rayfoto broadcasters as of 1928.

STATION	LOCATION
WMCA	New York, New York
CKNC	Toronto, Canada
CJRM	Moose Jaw, Saskatchewan
WJR	Detroit, Michigan
KMOX	St. Louis, Missouri
WFIL	Philadelphia, Pennsylvania
KFEL	Denver, Colorado
KSTP	St. Paul, Minnesota
KFPY	Spokane, Washington
KWCR	Cedar Rapids, Iowa
WFBL	Syracuse, New York
KXA	Seattle, Washington

first broadcast was on November 5, 1927, at WOR in Newark, NJ, then located in the Bamberger's Department Store and

operated by chief engineer Jack Popple.¹⁵ A display of a picture receiver was set up in the store to attract customers. The station must have taken a wait-and-see attitude as WOR does not appear on the table of regular broadcasters, but others jumped on the bandwagon. In some areas experimenters formed clubs where members could show off their best images and help new members get started.

To help the Rayfoto user get started, the kit included a phonograph recording of sample images. The picture receiver can be attached to the output lines of a phonograph, and the operator can test his receiver and practice setting the corona. The operator's manual and the articles in *Radio Broadcast* gave samples of image defects and adjustments required to cure them, for example the unwanted lines appearing in the image on the right side of Fig. 30.



Fig. 30. Rayfoto comparison with image defects. (*Radio Broadcast*, Vol. XII, Jan. 1928, p. 216)

Rayfoto Fades Away

After the period from late 1927 through 1928, very little appeared in the press about the Cooley Rayfoto System, most likely because, for the average radio fan, the operation of the system was not simple. A set up time was required for each program, which included hooking up batteries and developing the photographic paper that was used—and then there was a breakdown time. Obviously this was not an option for the “mom and pop” radio listener. Also, radio listeners without a picture receiver would have to listen to a few minutes of squeaks and squeals during the picture transmission period.

Since it never caught on in great numbers, it can be assumed that the Rayfoto system found it difficult to attract advertisers. It is also safe to assume many listeners would find another station during this time. That would certainly drive away even more advertisers. Therefore, if the small number of listeners using picture receivers drove away the advertisers, the lack of advertisers would cause broadcasters to stop the programming. If there is no programming of picture transmissions, there is not very much that one can do with a Cooley Rayfoto System.

The Next Fad: Radio Broadcast Facsimile

The Finch System

Inventor William Finch had experimented with facsimile beginning in the early 1920s. While working for the International News Service, one of the Hearst companies, he was awarded well

over a hundred patents.¹⁶ Forming his own company in 1935, Finch Telecommunications Inc., he promoted a different approach to sending images by radio. His idea was to send an extended picture message. The receiver would send information to a printer that would print from a long roll of paper (see Fig. 31), and this chemically-treated paper did not require any processing after printing. A diagram of the Finch System shown in Fig. 32 reveals some familiar concepts used in early fax machines from 1980–1990.

The Finch receiver would be activated by a timer after regular broadcast hours, and the subscriber would wake up to a newsletter or other information ready to cut off the roll (see Fig. 33). Finch made arrangements with several radio stations to provide broadcasting for his system, and his company prepared to sell subscriptions to customers in those areas.

In the 1920s, as radio broadcasting was rapidly expanding, newspapers provided nearly all the news service to the public. As radio vied for a part of the news service business, they ran into strong resistance from newspaper



Fig. 31. Finch Printer (Detroit News Archives)

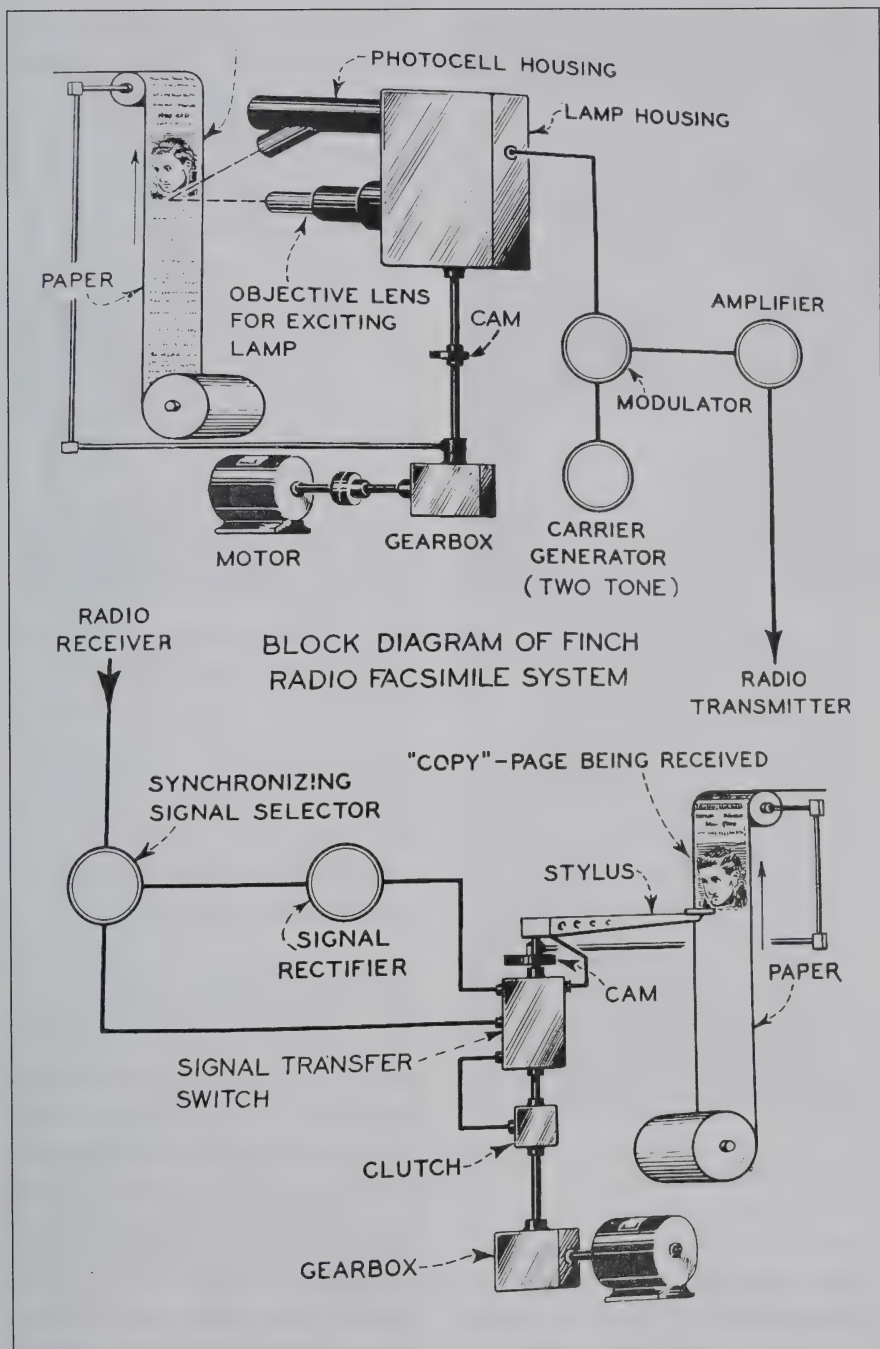


Fig. 32. Finch printer assembly. (Jack Poppele Scrapbook Collection, AWA Museum)



Fig. 33. System described as "So Easy a Child can Operate the Finch System." (Detroit News Archives)

publishers, who had little interest in sharing advertising dollars with the new radio stations. Radio broadcasters had to go as far as forming a news service of their own, Transradio News Service. It is easy to see why the newspapers would resist sharing content with new facsimile services—radio services could get information to the subscriber's home faster than a newspaper could be delivered. The difficulty obtaining good news content for the facsimile service would, in turn, make it difficult to keep subscribers. Fewer subscribers meant less advertising revenue to help support a facsimile system.¹⁷ Although other facsimile companies came and went, Finch held on for many years. It appears that a large part of his income was derived from patent

In planning your radio or facsimile "newspaper" avail yourself of the FINCH PATENT STRUCTURE

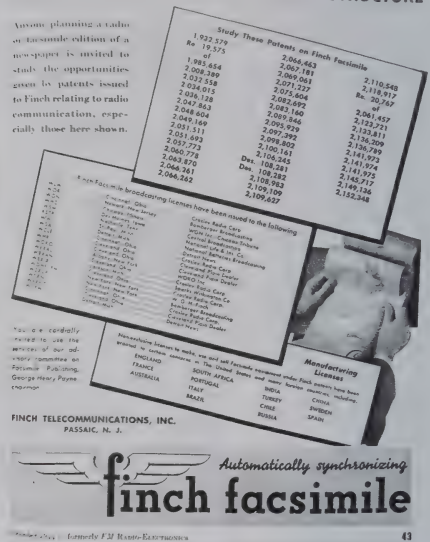


Fig. 34. Finch Telecommunications Inc. advertisement. (*FM and Television*, Volume 4, No. 11, 1944, p. 33)

licensing, as shown in his trade advertisements, one of which appears in Fig. 34. One of these licenses would go to one Powell Crosley, Jr. Crosley's "Reado" system is described next.

Introducing the “Reado”

Powell Crosley Jr., the widely proclaimed "Henry Ford of Radio," became a believer in radio broadcast facsimile to the home during the period from 1938 to 1940. Always mindful of his market in rural America with other products such as the "Icyball,"¹⁸ he believed that listeners who were unable get a daily newspaper would like a newsletter appearing at the back of their radio every morning. After procuring a license on the Finch system, he began broadcasting from his

experimental radio station W8X0 and soon his station WLW, which had coverage over a large part of the country. He also convinced WOR chief engineer Jack Poppele to begin test broadcasts. Facsimile prints were sent from the New York City area to Crosley in Cincinnati and from Crosley back to Poppele. Soon WGN joined as a facsimile broadcaster and eventually thirteen broadcast stations were equipped to transmit facsimile. These broadcasters were part of the Mutual Radio Network. If Crosley could maintain regular programming by a network of facsimile broadcasters, his plan could be a success. The experimental broadcasts found that the printer was sensitive to static. A burst of static could send a few feet of paper advancing through the system. Experiments showed that shortwave transmissions were more stable. Other stations joined the testing, and plans were made for regular transmissions on AM radio. The FCC gave permission for facsimile transmission after regular broadcast hours on the AM band and at all hours on shortwave band from 25 to 47 MHZ.¹⁹

Crosley introduced his receiver model 758-A, which was a dual-band AM and shortwave radio with an output for the printer (see Fig. 35). The printer model 118 shown in Fig. 36, named the Reado, was listed to sell for \$79 or \$59 as a kit. The owner could place a timer inside the Reado to start the reception in the early morning hours (see Fig. 37). Crosley set up an assembly line at his Arlington Street assembly plant, which was capable of producing a hundred units per day.²⁰ Reado printers were shipped to Crosley



Fig. 35. Crosley Reado promotional material. (Composite of ads, *AWA Review*, Vol. 16, 2003, pp. 85-86, and the author's collection)



Fig. 36. Crosley Reado Model 118. (Author's collection)

dealers, who were ready for the buyers to line up at the door. As units were shipped to Crosley dealers in areas able to receive transmissions, it was discovered that the Reado image quality left

Pictures by Radio for the Home

much to be desired when compared to newspapers. In addition to the narrow print, line drawings were used because

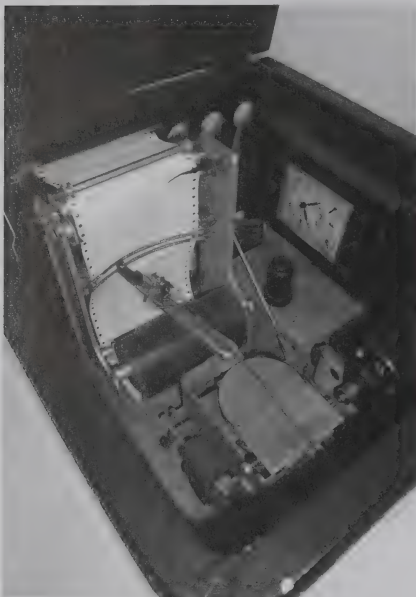


Fig. 37. Reado with user-supplied timer added. (Author's collection)



Fig. 38. Reado printout sample. (Author's collection)

photographs did not reproduce well (see Fig. 38). As time passed, Crosley waited and waited for the buyers to line up at his dealerships. After all of Crosley's effort to provide program content, schedule transmissions, form a broadcast network, manufacture the receiver hardware, and market the Reado printer at a reasonable price, Crosley was unable to generate customer interest.

Commercial Pictures by Radio

Some of the earliest work to send pictures by radio is described in a text by Marcus J. Martin, in 1921.²¹ Martin describes a crude system with a rotary spark transmitter and a receiver using a coherer. No sample images appear to exist for this system. The early work by RCA, including the transatlantic picture transmission of 1924, demonstrated that a point-to-point radio facsimile service was possible. Two years after that demonstration, a commercial service was started in 1926 from New York to London, and research continued. Service was then expanded, as arrangements were made to work with other companies using compatible equipment. RCA teamed with Marconi, Siemens, Cables & Wireless, Telefunken, and Reich Post to initiate the point-to-point service shown in Table 2.²²

An RCA publication titled "Radio Facsimile" collected articles by the research staff and presented a detailed picture of radio facsimile development. The result of this work was demonstrated in a side-by-side comparison of a transmission using the 1924 equipment, next to the same image using the 1938 equipment (see Fig. 39). It was the RCA

Table 2. RCA international point-to-point Radiophotogram services.

City	City	Date Initiated
New York	London	May 1, 1926
New York	San Francisco	May 15, 1929
Berlin	Buenos Aires	June 9, 1930
New York	Buenos Aires	Aug. 8, 1932
New York	Berlin	April 18 1932
London	Australia	Oct. 16, 1934
London	Buenos Aires	Jan. 1, 1937

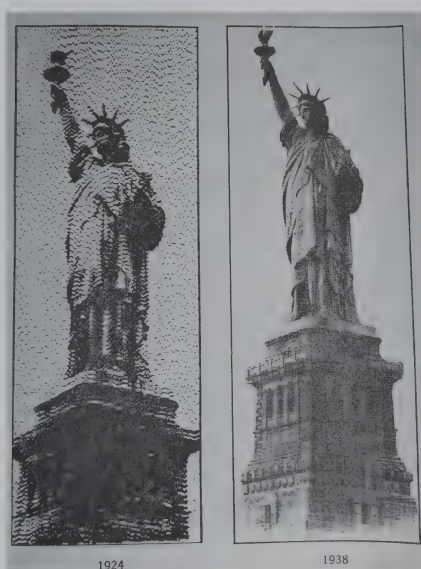


Fig. 39. Comparison of RCA transmissions 1924 (left) and 1938 (right). (*Radio Facsimile*, Vol. 1, 1938, p. vii)

Communications Division of RCA that carried out this work. Many top RCA researchers were involved, including Vladimir Zworykin. All aspects were investigated: the printer types, papers, electronics, photocells and scanners. An article written by noted radio engineer

and RCA consultant Alfred Goldsmith stated that the value of this research was as a stepping-stone toward television. He noted the restrictions caused by the technology available at that time, and he pointed out that because facsimile would need only 1% of the bandwidth required for a good television picture, a radio facsimile service was a more achievable goal.²³

Much of the research to achieve the improvement demonstrated in the comparison of images from 1924 with those from 1938 was presented at meetings of the Institute of Radio Engineers (IRE) by the engineers leading the different areas of research. There were five such presentations documented in the *Proceedings of the Institute of Radio Engineers*.²⁴ They also tested different modes of modulation, settling on phase modulation. They transmitted a regular series of pulses and varied the pulse width in accordance with the intensity of the scanned signal. A pulse width could be varied from 10% to 90% of space between pulses to print a range from white to black.

Pictures by Radio for the Home

As early as 1926, RCA demonstrated the ability to add an image to their radio-grams. This example of a Radiophotogram showing a policeman on a truck is in the collection of the Museum of Modern Art in New York (see Fig. 40). In 1938, with their technical advances proven, RCA was confident that broadcast facsimile had improved to a degree that home facsimile service would achieve market acceptance. A facsimile scanner was designed and produced for broadcasting stations (Fig. 41), and a home receiver was also introduced (Fig. 42). A number of broadcast stations purchased the Facsimile Scanners, and the Facsimile Receiver was intended for the home market. Unfortunately, as the depression years dragged on, the RCA effort, like that of others, suffered the same lack of public interest. During the 1930s, RCA continued to improve and expand commercial radio picture and radiogram service. RCA planned and constructed an ultra-high frequency network between New York and Philadelphia, which is shown schematically in Fig. 43.

John V. L. Hogan was a noted radio engineer and entrepreneur. In 1937 he founded New York Radio Station WQXR. In 1939, FM transmission was added to the WQXR radio service. Hogan, through his company, Radio Inventions Inc., began experimenting with a facsimile system over FM. As technology had advanced, FM transmission held the promise of faster transmissions of higher quality. Soon all work toward facsimile broadcast went on hold as consumer electronics production was halted by World War II, and Hogan and others

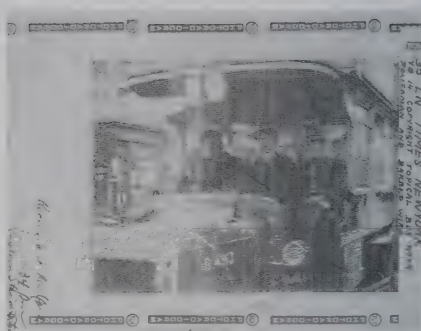


Fig. 40. RCA Photoradiogram circa 1926. (www.moma.org/collection/works/58675)



Fig. 41. RCA scanner. (St. Louis Post Dispatch)



Fig. 42. RCA home fax receiver, 1938. (Wide World Photo)

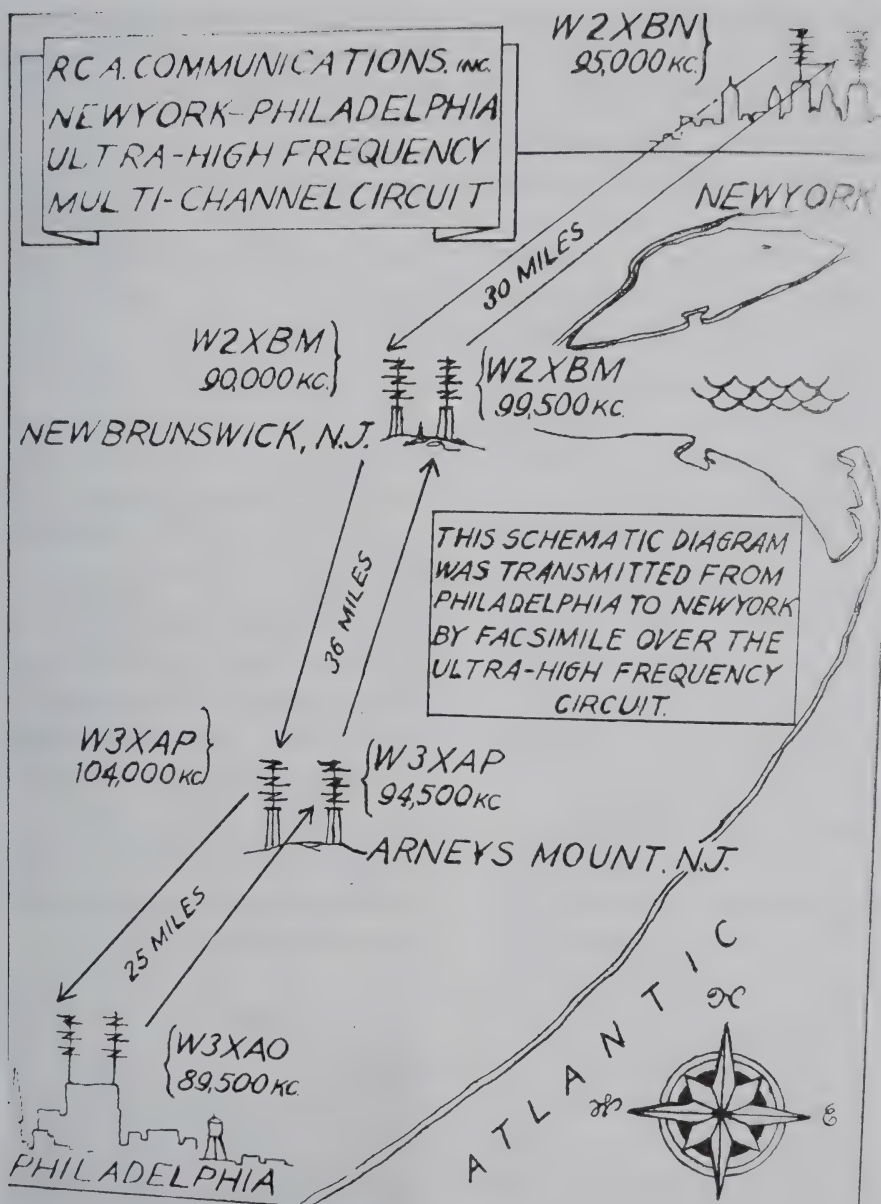


Fig. 43. RCA Communication's facsimile network, New York to Philadelphia. (*Radio Facsimile*, Vol. 1, 1938, p. 214)

went on to perform research for the military effort.

After the war, FCC approval was granted, and a frequency allotment was made on the new postwar FM band. The high end of the FM band, 106 MHz to 108 MHz, was designated for facsimile and facsimile services that had started up. Research by Hogan and others continued into the latter half of the 20th century. Fax service could be transmitted on a FM subcarrier at a faster speed and with a higher image quality with no interruption to a listener. In the 1970s, RCA researched providing a fax service piggybacked onto the standard TV signal. A proposal was made to send facsimile data during the vertical interval reference (VIR) part of the NTSC standard TV signal,²⁵ just as closed captioning was later provided. A printer attached to a TV for facsimile service never came to pass.

Mr. Cooley After Rayfoto

As the concept of radio pictures for the home was fading from the scene, there was a brief effort by the Rayfoto Company to enter the mechanical TV field. They introduced what was promoted to be an improved neon tube for television imaging and some scanning discs. One unusual disc had a series of pins around the perimeter that were intended to receive an arc from the corona generator and project an image of the arc onto a small screen. How this would work was unclear, and none of their equipment appears to survive today.

Austin Cooley then began working for the Times News Service, World Wide Photos, where he worked on systems for

a Wirephoto Service and Radiophoto Service for newspapers. In 1935 he made news himself when he responded to the news of the crash of the Macon, a navy dirigible. Cooley was able to take pictures of the survivors being brought ashore, which he then sent across the country by radio. This was the first such transmission.

Throughout a long career, Cooley worked on systems to transmit weather maps, medical x-rays, photographs, and other facsimile materials. During World War II, he worked with the military to develop systems to send maps and weather maps to the commanders in the field. He was later honored by the War Department for this work (Fig. 44). During the 1950s, he was vice-president of the Times Facsimile Service, where he developed systems for sending weather maps by radio to ships at sea. In 1959 Litton Systems purchased the facsimile business from The New York Times Company. Cooley moved to Litton and as years went by he worked on systems to transmit images using early communication satellites.



Fig. 44. Military use of facsimile receiver. (*The Rise and Fall of the Fax Machine*, 2015, p. 78)

Austin Cooley was awarded 75 patents over his long career and among other awards received the Marconi Medal from the Veteran Wireless Operators Association. He also received the DeForest Club medal. He passed away in 1993 at the age of 93.²⁶

Conclusion

As we have seen, there are many good arguments for claiming that the Cooley system was a valid link in the chain as radio progressed to television. The Cooley system was made available in both kit and assembled form, and radio stations in many cities transmitted programs with pictures to homes on a regular schedule. It is part of a continuous line of development that is preceded by early pictures by wire, then by commercial pictures by radio. After the Cooley system, others continued the line of development to offer radio facsimile for the home as well as commercial photo services. Austin Cooley himself had a long and distinguished career in facsimile transmission.

None of the home facsimile services ever seemed to catch the public's attention enough to become economically viable. Home and office point-to-point fax machines connecting over phone lines hit their peak some years ago. Now, with the exception perhaps of lunch menus, much of this service is shifting to the Internet. Today one can make the argument that the Internet is providing too much of this service, but just as with the earliest work in 1842, images are still taken apart one pixel at a time, transmitted, then put back together again.

For myself, I have to think back on opening that box for the first time. I never would have guessed that I would get so much from the few parts in a box labeled "Cooley Rayfoto System of Radio Pictures for the Home."

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14. Rayfoto Co. Sales brochure; see <http://www.earlytelevision.org/pdf/rayphoto.pdf>.
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18. Crosley bought the rights to the Icyball refrigeration idea, and brought it to market. Powel Crosley had a gift for recognizing great ideas and a gift for marketing. See "Crosley Icyball" at

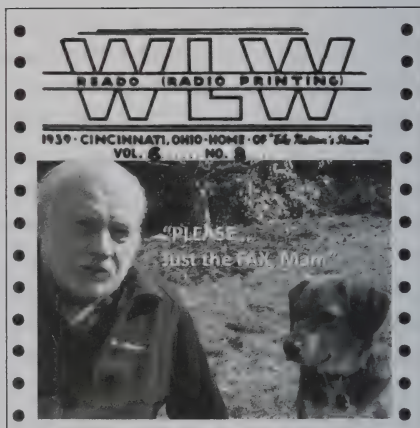
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About the Author

Mike Molnar founded Diagnostic Services Inc. in 1983, and it still keeps him busy building nuclear medicine gamma

cameras for veterinary clinics around the world. Mike also finds time for the care and feeding of a 40-year collection of electronic fossils. Once again, Pam, Mike's understanding wife, had to hear Mike say, "I don't think this article will take too long." This year, with the help of his faithful assistant Lila, many electronic fossils will be shared with the public in a display at the local library and in a long-term exhibit at The Red Mill Museum, Clinton, NJ.



Author **Mike Molnar** (left) and Lila.

Radio & TV Graphics: Magazine Ad Illustration Art

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The “golden age of radio” (and later television) also coincided with the “golden age of magazines” and the blossoming of the advertising business. As advertising agencies were experimenting with how to make the best use of expensive magazine ad space for product promotion, many creative techniques were employed to grab the reader’s attention and get potential consumers to buy their products. This article will take a look at twenty of those techniques and show how they were employed to create visually appealing radio-phonograph-television ads starting from the early 1920s on through the 1970s.

Introduction

Many radio collectors have found the attraction of old magazine ads to be irresistible. Is it because of the rekindled nostalgia for the products or services pictured, or just something about the captivating artwork itself? This author has found both to apply, and as a bonus, advertisements take up much less storage space than the radios pictured.

For the greater part of the 20th century, magazines such as *Life*, *Look*, *Saturday Evening Post*, and *Ladies Home Journal* were a major source of entertainment and information. For youngsters growing up in that era, those old, colorful, full-page, magazine ads were a pleasure to look at and much more interesting than today’s annoying popup web ads.

Vintage advertisements have been a rich source of material for an endless plethora of coffee table books starting with titles such as *All American Ads of*

the 20s, *All American Ads of the 30s*, etc. Many just concentrate on automobiles (*Ads that Put America on Wheels*; *Cruise-O-Matic*; *Retro-Ride*), and one exclusively covers the VW Beetle: *Remember Those Great Volkswagen Ads?* There are product-specific books covering ads by Coca Cola, Pepsi Cola, Lionel Trains—and even Absolut Vodka. There are two books that contain ads for vintage phonographs, and another focused on TVs: *Window to the Future: The Golden Age of Television Marketing and Advertising*. Sadly, no books are available that consist entirely of vintage radio magazine ads.

Believe it or not, old radio ads were actually the topic for a Ph.D. dissertation titled *Examining Radio Receiver Technology Through Magazine Advertising in the 1920s and 1930s*, which was written by Thomas W. Volek for his 1991 University of Minnesota thesis.¹ By analyzing hundreds of old magazine ads, he was able to

use them to document the evolution of radio technology. He used so many, in fact, that he had to incorporate a second bound volume just to contain them all.

"Radio Advertisement and Fashion," Barbara Havranek's article in the 2005 *AWA Review*,² provided a thoughtful overview of the history and development of the magazine advertising business, with an emphasis on how women were used as visual props to help spark consumer interest.

In the early 1920s advertising agencies were experimenting with how best to make use of costly magazine ad space. Products such as automobiles, perfume or cereal made use of large, attractive, poster-like graphics, but the highly technical nature of early radios required more explanatory text, making them more challenging to compose and illustrate.

W. Livingston Larned, in his 1925 book, *Illustration in Advertising*,³ identified 36 techniques that were used to create a visually appealing ad. His book will be used as a starting platform to create a simplified list of twenty styles. They were by no means unique to any ad and were usually used in combination with each other for greater effect.

1. Family Situations

Just as with the cell phone/computer evolution of today, it was primarily younger people who became the early adopters because they were more eager to learn how to wire up and fiddle with a radio. How do you hook up the "A" and "B" batteries, how do you coordinate all of the many radio dials, and how do you make an effective antenna, were just a

few of the challenges for the first radio pioneers. And many times it was only the person wearing headphones who could actually listen to the broadcast.

Women of this era generally stayed at home to run the household and therefore had a strong say in deciding home product purchases. So, ads had to convince them that a radio could be an essential part of the household, by bringing the news and also serving as an entertainment center. More importantly, manufacturers had to show that a radio would be easy for a woman to use, and also be an attractive addition to the family's existing furniture.

Ads showing families with children and grandparents actually tuning a radio put potential buyers at ease, so it is no surprise that a great many ads featured them prominently in their artwork. RCA shows in Fig. 1a how using the radio is easy and fun for the immediate family; in Fig. 1b RCA pictures a grandmother and her grandson bonding over the excitement of listening to a radio. In this case grandma actually appears to be the one introducing her grandson to the new technology.

As the technology matured and radio started broadcasting "soap operas" (so called because they were mostly sponsored by soap companies), it was not unusual for some listeners to become emotionally involved with the story as they listened. General Electric pictured this kind of scene in their ad titled, "Don't Cry Mother . . . It's *Only* A Program!" (see Fig. 1c).

At the dawn of the age of television Norman Rockwell was easily one of the

“hottest” and most recognizable artists of his time. Not only did he produce more than 300 covers for the *Saturday Evening Post*, but he also produced memorable advertising art such as “Look Ma, no cavities” for Crest toothpaste and cereal box art for Kellogg’s Corn Flakes. Dumont Labs employed his services to create family-friendly ads illustrating how television could actually bring families together, something that Norman Rockwell could do better than anyone else.⁴ In Fig. 1d, titled “Enchanted lands. . . right in your home,” he charmingly pictures two children and their pet cocker spaniel watching an unseen Dumont television.

2. Serialization

Most ads were one of a kind, in the sense that the style of artwork and advertising message that appeared one month was completely different the next month (or the next advertising cycle). There were, however, some cases where the illustrator developed a recurring theme whereby the characters or settings were repeated but the text and products changed.

In some cases, ads were actually labeled as being part of a series. This was the case for Universal Microphone, Western Electric, and Philco in most of the ads they published during the war years. For example, those for Universal Microphone had the following text in tiny font under their artwork: “History of Communications number xx of a series.” Most of the time, however, series numbers were never indicated or implied.

One of the earliest and best examples of this technique is RCA’s series of 39 folksy ads created by David Hendrickson

(1896–1973). They were directed at the rural farmer, so they primarily appeared in *Country Gentleman* and *Successful Farming* magazines. However, occasionally a few of them having a wider audience appeal were also found in the *Saturday Evening Post*. Some of the *Country Gentleman* ad headlines were:

- “Radiola 20 for bigger farm profits” (see Fig. 2a)
- “You can make Radiola 20 pay for itself in better crops” (see Fig. 2b)
- “The dependable Radiola 20 enriches every side of farm life”
- “You can make your farming more profitable with a Radiola”
- “Radiola 20 gives farm life new pep”

3. Pen and Ink Art

Black and white art was the most prevalent, not surprisingly because it was less costly. This style was occasionally augmented by using a second color (usually red) to create more reader interest at a modest additional cost. From the early 1920s, when Philco sold only batteries, through the 1960s, a large part of Philco’s budget was committed to black and white. In Fig. 3a Philco uses nostalgia as a sales tool by picturing a grandmother remembering the “good old days” while listening to a radio.

Fada emphasized the superior sound quality of their sets with this ad titled “If Mozart could hear ‘The Magic Flute’ on a Fada Neutrodyne—his trained ear would approve the tonal fidelity to the original in his famous opera.” Using simplistic sketch art, it depicts a nymph playing a flute (see Fig. 3b).

For some consumers, buying a radio was a dramatic adventure, so Freed-Eisemann's ads exploited this feeling by using strong imagery. One such ad, titled "Study the Circle," goes on to say "By official figures, it proves the overwhelming public preference for Freed-Eisemann." The seagoing sailor provides a sense of bravery and courage to which the prospective equipment buyer can relate (see Fig. 3c).

4. Fine Art

The term "fine art" may be a stretch in the context of magazine advertising, but for this article it will be defined as artwork that appears more intricate and refined than the norm. Arguably, that still leaves much room for personal interpretation (and debate).

RCA was a very prolific advertiser and spared no expense when it came to hiring highly regarded commercial illustrators. Everett Shinn's RCA ad is one example that shows a Radiola being used as the entertainment for a well-to-do family's social gathering (see Fig. 4a). The illustration demonstrates the versatility and ruggedness of RCA's radio as well as the ample volume of RCA's speakers.

Brandes, an international manufacturer of radios and speakers, published an interesting ad in the British magazine *The Sphere*, picturing a woman casually lounging in a chair next to a Brandes cathedral speaker (see Fig. 4b). The illustration looks like something that might have been borrowed from a museum display, with the following explanatory text at the bottom: "The new Brandes 'Ellipticon' Cabinet Loud Speaker will

bring the Christmas dance music to your home better than anything you have ever heard."

The use of "fine art" as an integral part of a sustained advertising campaign was not a new idea. One of the early pioneers of this technique was Charles Coiner, the vice-president of the N. W. Ayer advertising agency, which represented Victor Red Seal Records, De Beers diamonds, and Capehart/Farnsworth, among many others.

In 1939, Coiner designed an ad campaign for DeBeers that was aimed squarely at using a snob appeal. By using the talents of noted commercial artists to create tasteful artwork with the tag "painted especially for the DeBeers collection," these ads resulted in increased sales by giving their diamonds a sense of elegance.

Sensing a winning theme, in late 1941, Coiner expanded this approach to Capehart. During wartime, production of consumer goods was limited or non-existent, but Capehart still needed to keep their name in front of consumers for the time when production resumed. By enticing the public with advertising art that was attractive enough to be displayed, they created a way to stay in the minds of consumers long after the magazine was discarded. To encourage this, near the bottom of these ads in small print was the following statement: "Reprints of previous paintings in the Capehart Collection, suitable for framing, are now available from your Capehart dealer at a modest charge." The "Capehart Collection" referred to the fact that the artwork reprints were

sent out in predefined groupings (a.k.a. “collections”) of roughly six ads, and every collection was given a letter name “A” through “H.”

Capehart’s artwork was loosely based on the artist’s interpretation of a musical composition, and Fig. 4c shows Raymond Breinin’s interpretation of Claude Debussy’s composition, *The Engulfed Cathedral*. Wartime ads, such as this one, also included some explanation of the current production status:

“The building of the Capehart has ceased, and the research laboratories and vast plants of the Farnsworth Television & Radio Corporation are engaged solely in war production. Unless you now own a Capehart, or purchase one still remaining in dealers’ showrooms, you must wait until victory to enjoy this superlative instrument.

“But you can prepare for the war’s earlier end by buying War Bonds! Your country needs your investment, and you will be building soundly for the future, when you want to purchase a home, a car, an airplane, a television set, or a Capehart.”⁵

The Capehart Collection campaign extended into 1947 with a total of 51 different ads by many well-known artists of that era. One even featured the work of Salvador Dali. Magnavox, Upjohn pharmaceuticals, Abbot Laboratories and many other companies quickly picked up on this technique and it became a very popular industry trend until the end of that decade.⁶ “Great art” by “the masters” was also a frequently used

tongue-in-cheek merchandising tool. How many times have we seen the Mona Lisa exploited in magazine ads or on TV? Koss even used her in one of their headphone ads in 1980.

Fisher Electronics did something similar. After they became a division of Sanyo of Japan in the late 1980s they “repurposed” Vincent Van Gogh’s 1889 self-portrait—bandaged ear and all—to promote the sound quality of their stereo equipment, using the tagline, “Had Van Gogh owned a Fisher, he might have thought twice” (see Fig. 4d). This was meant to imply that the music Fisher stereos produced was so good that Van Gogh would never have wanted to sacrifice his ear had he been alive to hear Fisher’s performance.

5. Slogans

Having a catchy slogan associated with a product line is a popular way to create brand loyalty. Some became so ingrained that they immediately come to mind for baby boomers fifty years after the fact—for example, “You can be sure if it’s Westinghouse,” or in the case of General Electric, “Progress is our most important product.” Slogans can also be used to provide a natural theme for companion artwork.

All slogans have a life expectancy. Companies change. Products change. So it is not unusual for a company to be noted for more than one slogan. Crosley used three different slogans in their marketing campaigns over the years, but the longest running slogan was “You’re there with a Crosley,” which ran from September 1927 through June 1940 (see

Fig. 5a). The implied message was that one could always count on Crosley radios to keep informed about important sporting and news events.

When Philco introduced their “slant front” console radios in 1937–38, their accompanying slogan, “No squat, No stoop, No squint,” reaped a bonanza in press coverage and subsequent sales. By humorously picturing people in extremely awkward and embarrassing poses while attempting to tune a conventional radio (Fig. 5b), Philco very effectively demonstrated how their radios were much more ergonomically accessible.

Hallicrafters employed the slogan “Meet your new neighbor . . .” to promote their multiband shortwave radios. During and after World War II, Americans read about strange countries that either became theaters of battles or friendly bases for our soldiers. All of this spawned a natural curiosity. Hallicrafters’ radios were the perfect way to tune in to the war news and, presumably, get acquainted with our “new neighbors.”

Each colorful Hallicrafters ad featured a different, and in most cases, exotic country. One classic ad pictures a snake charmer (Fig. 5c) with the slogan followed by these four descriptive sentences: “India is the meeting place of the Orient and the Occident. Land of Rajahs and snake charmers, of snow capped mountains and steaming jungles, it is a nation of many contradictions and seeming perplexity . . . But many countries are unusual and mysterious only because they are not known. Familiarity makes for understanding . . .”

Motorola used at least five different slogans in the 1950s and 60s to promote their television products. Their longest running slogan was “More to Enjoy,” a strictly black and white photo ad campaign featuring stereotypical family/home situations. These ads tried to snapshot typical events taking place during this baby-boom cycle: babysitting, a wife’s shopping spree, a sock hop party, and others. In all, Motorola ran 37 different “more to enjoy” ads in the *Saturday Evening Post* from July 1957 through May 1959.

“Fresh from Motorola . . . new leader in the lively art of electronics” was their most colorful and dramatic ad campaign of all; it appeared in 22 issues of *Life* magazine from March 1961 through October 1963 (see Fig. 5d). These ads illustrated futuristic space-age homes containing mid-century modern furniture skillfully drawn by Charles Schridde (1926–2011), and projected Motorola’s foresight in design, style, and performance.

6. Humor

Humor in the form of cartoon art has been used in the past primarily to sell tubes, speakers, and repair parts, but not so much for radios (or TVs for that matter). RCA was one of the earliest companies to use cartoons in their advertising. Rea Irvin (1881–1972), a pioneering artist for the *New Yorker* magazine, created twenty ads for them from 1924 to 1926 using the simplest of cartoon characters to sell RCA’s Radiotron tubes and horn speakers (see Fig. 6a).

During the war years, Echophone made use of cartoon art to promote their

EC-1 shortwave radio (see Fig. 6b). Starring an “everyman” type of character with the unlikely name of Hogarth, Echophone’s ads were designed to distract the reader from the day-to-day war news and bring some humor into the home. They were mostly found in *QST* magazine, but some could also be found in *Radio*, *Radio News*, and *Radio-Craft* magazines from 1941 to October 1945.

The Utah Radio Products Company used Kellogg’s Rice Krispies artist Vernon Grant (1902–1990) to create a whole series of cute ads employing those very same, but unnamed characters to help sell their speakers. One example that appeared in a 1944 issue of *Fortune* magazine, which is shown in Fig. 6c, presented Utah’s post-war product sales strategy to the public with the slogan, “What will they think of next?” In 1945, Vernon created seven more of these ads for both *Radio News* and *Radio & Television Retailing* magazines.

African-American artist E. Simms Campbell (1906–1971) was a major contributor of *Playboy* magazine’s adult cartoons. In 1938, he produced one colorful Playboy-style cartoon ad for Westinghouse featuring a very happy sultan and his beautiful harem titled “Westinghouse cozy-corner ensemble” (see Fig. 6d).

7. Dark Backgrounds

Philco’s use of dark backgrounds in their black and white photo ads gave them an almost eerie quality, creating a distinctive “Philco Noir” style. Most of them pictured an attractive woman dressed in a formal gown standing (or seated) next

to one of their radio consoles in a very dimly-lit setting. The only missing elements are Humphrey Bogart and perhaps Casablanca’s Rick’s Cafe (Fig. 7a). Philco used this “noir format” for more than ten years to sell their radios, televisions, and refrigerators.

Admiral also gave this style a try for a few of their ads, but they were not afraid to use full color. They published a sexy ad “announcing a new world of sound” to tout Admiral’s new 1959 stereo hi-fi speaker systems (Fig. 7b).

8. Suggesting by Inference

Some ads are so subtle in appearance that it is difficult to determine if they are really ads at all. In cases where ads are so disguised that they blend into the background copy, it is not unusual for the publisher to put a tiny heading “advertisement” at the top of the ad to alert the reader of that fact. In 1929, Kolster ran such ads in the *New Yorker* and *Vogue* magazines that managed to blur the lines between entertainment and advertisement.

Kolster’s 1929 *Vogue* ad “Behind the scenes at a Country Club” pictures two men chatting about their wives’ product brand choices in jewelry (see Fig. 8a). No radio is pictured and Kolster is barely mentioned. An excerpt from the ad identifies it as a Kolster ad: “...and now both selected a Kolster radio, because both fell in love with the distinguished beauty—the rare craftsmanship—of a Kolster cabinet.” This sentence is followed by “(Its mechanical excellence, of course, was never questioned.)”

In similar fashion, Kolster’s 1928

New Yorker ads were well disguised as cartoons drawn by the distinguished artist Peter Arno. The example in Fig. 8b shows two characters, Gold-Digger and Sugar-Daddy, having a conversation, and then Sugar-Daddy promises, "I'll get you one of those Kolster radios somehow." This technique did not appear to work very well for Kolster because they went into bankruptcy by the end of that year.

9. Poster Style

Posters, and by extension poster art, never caught fire in the United States, although they were immensely popular throughout Europe. On the internet, one can find many terrific posters for foreign radio manufacturers such as Telefunken, Blaupunkt, and most notably, Philips.

There have been a few instances where American companies have come close to using a poster-like style to create interesting ad campaigns. The Sparks-Withington Company, maker of Sparton radios, is one of them. In 1929 they created twelve visually dramatic two-color ads (black and red) for *Liberty* magazine. The subject usually featured a musician (e.g., xylophonist, accordianist, violinist, guitarist, drummer), but a baseball player and Santa Claus were thrown in for seasonal appropriateness. The September ad is titled: "Face-to-Face Realism" (Fig. 9a), and it goes on to say: "A glorious new 'something' in radio reception. The glow of warm, living personality has been captured in the new Sparton Equasonne instruments."

From 1971 to 1978, Marantz experimented with psychedelic-style art, even offering poster versions of some of them

to readers of *Rolling Stone* magazine. One classic pictured a heavily-muscled barbarian in active combat with the title "Marantz slays foul sound" (see Fig. 9b). This was so popular that it was also made available on a T-shirt. Most of Marantz's other psychedelic ads were exaggerated caricature portraits of people. *Stereo Review*, *Audio*, *High Fidelity*, and *Playboy* magazines carried these same ads month after month to the point of excess.

Sansui, trying to one-up Marantz's approach, used two of Jacqui Morgan's psychedelic designs to convey their product messages.⁷ They look like an LSD trip that ended badly. One such ad with the tagline "Who controls your four channel destiny?" appears in Fig. 9c. Another with the line "Birth of a new era" (not shown) did not appear to go over very well in accomplishing their goals because this ad campaign ended as quickly as it started.

10. Historical Themes

Using history to promote products is an overused sales tactic that is still endured every February during the slew of Presidents' Day sales. A look back at some vintage radio ads proves that this sales gimmick was well established long before our time. This approach usually results in "cookie-cutter ads" that pose the question "what if?"

Philco published a long series of historically-themed ads throughout 1935 in *American Magazine*, *Colliers*, and the *Saturday Evening Post* to advertise their model 116X. Their illustration of Paul Revere's famous ride through Boston seen in Fig. 10a claims to show how radio

could have spread the word about an impending British invasion more quickly if radio had been available at that time. Others featured Patrick Henry, Jenny Lind, Francis Scott Key, Marco Polo, DeWitt Clinton, and many other famous people. In 1939, RCA derived inspiration from an earlier ad by their rival, Philco, and created one that said: “Paul Revere could have stayed in bed,”—followed by “Had radio broadcasting been available in 1775” (see Fig. 10b).

Ten years prior, in 1927 and 1928, Grebe created a long ad campaign around the history of communication techniques used over the past millennia such as smoke signals, beacons, carrier pigeons, and semaphores. They all stressed the value of having good communications equipment and how one could “get it better with Grebe.” Needless to say, one of them (not shown) also featured the exploits of Paul Revere.

11. Cross Branding

Sometimes a “partner company” was mentioned in an ad. The purpose would be to highlight a complementary product or to give credit to the provider of an advertising prop, such as a formal gown worn by one of the female models.

Since RCA’s Radiotron tubes could be used in anyone’s radio, to maximize sales, RCA ran a campaign from 1929 to 1931 featuring photos of prominent CEOs of competing radio manufacturers, even though some were actually competitors in that marketplace. Approximately twenty different executives were spotlighted over the years, including Zenith’s Eugene McDonald shown in Fig. 11a, Grebe’s

Alfred Grebe, FADA’s Frank Andrea, and McMurdo Silver.

Marlboro and RCA teamed up to produce a two-page spread highlighting both of their similarly-sized products in *Esquire’s* November 1960 issue. Each page shows the same stereotypical “Marlboro man.” One page draws attention to the cigarette pack and the other page features the pocket-sized transistor radio (see Fig. 11b). The clear implication was that both products could be carried around with the same ease and convenience.

Philco’s Safari transistor TV shown in Fig. 11c was a prominently-featured accessory in Van Heusen’s ad for summer shirts in *Esquire’s* June 1960 issue. This ad bears a striking resemblance to the Beach Boys’ “Safari U.S.A.” album cover, which was not released until three years later. Who knows? Maybe this Van Heusen shirt ad became Brian Wilson’s inspiration for that song? Van Heusen’s ad went on to state, “Philco’s battery-powered Safari portable TV and Van Heusen’s style powered leisurewear get together for the fun of it.”

12. Formal Wear

If old magazine ads and TV shows were the only way to peer into our past history, one would get a very distorted vision of life as it was the 1940s and 50s. Most radio and TV ads of that period seemed to picture a woman in a prom gown, and sometimes a man stood alongside in a suit. A future historian might reasonably assume that formal gowns were required attire when interacting with this technology. Obviously, that scenario is pure fantasy

and just as hokey as the situation comedies portrayed on the *Ozzie and Harriet* and *Leave it to Beaver* television shows.

General Electric used the formal-dress motif exclusively to advertise their Musaphonic series of console radios in the post-WWII years from 1945 to 1948. The gowns used in their ads were so elegant that their designers (e.g., Cecil Chapman, Saks Fifth Avenue, Bergdorf Goodman) were also given credit in the small text beneath the photos (i.e., they also employed cross-branding as a strategy). Two ads typical of this style reproduced in Figs. 12a and 12b show how RCA and Zenith made use of this technique to showcase their products.

13. Fashion Illustration

Fashion illustration, a style defined as sketch art used to convey rough design ideas, was generally employed in perfume and clothing advertisements. Radio-TV manufacturers, on the other hand, used this art form very sparingly. Admiral bravely chose to break the mold, and from 1951 to 1953 they made use of this style for most of their ads, two of which are shown in Figs. 13a and 13b. Later, a few others such as Motorola, Dumont, and Magnavox tried this style for a few of their ads, but their ads were not nearly as polished as those of Admiral.

14. Glamour

The pairing of attractive women with a manufacturer's products to attract attention has been practiced from the dawn of printed art. Coles Phillips (1880–1927) was a noted magazine cover artist for the 1920s version of *Life* magazine, and, like

Rockwell, he also created a large amount of commercial art. Most of his work featured an attractive female whose clothing subtly blended into the surrounding background. This unique artistic style was dubbed “the fadeaway girl.” Such is the case with the ad he drew for Carola phonographs in 1916 (see Fig. 14a).

McClelland Barclay (1891–1943) was another famous artist noted for his attractive depictions of women, most notably in ads for the Fisher Body division of General Motors. He also created a few ads for Atwater Kent and Columbia Records. One gorgeous ad from a 1926 *Literary Digest* pictures a young lady casually lounging next to Atwater Kent's model 30 “coffin style” radio (see Fig. 14b) with this accompanying text: “Here is radio's greatest thrill—a touch of your fingertips and one dial finds anything on the air within range . . .”

In 1930, Crosley first introduced ads with the headline “Beauty” that showed an attractive woman wearing a swimsuit. The strategy was to encourage customers to associate the word “beauty” exclusively with Crosley's radios. In 1940, to celebrate twenty years in the business, Crosley produced a series of “glamour-tone” radios that prominently featured an attractive woman nearby (Fig. 14c) with this text: “Cities like Paris and Hollywood have GLAMOR. You can find it in certain ships and trains – and in people – in athletes, in actors, and in statesmen, in men of great personality and in women of unusual beauty and charm . . . and there is GLAMOR in the tone of the Crosley Anniversary Radios for 1941 . . .”

For their post-WWII radio sales program, Bendix chose “Beautiful beyond belief in tone and styling” as their theme. All of these ads included an attractive lady in the foreground to accent Bendix radios (see Fig. 14d).

15. Art Deco Style

Modern “abstract art” started appearing in the early 1900s, and many of the artists most associated with that style, such as Picasso, Degas, and Braque, are household names today. To capitalize on the avant-garde movement, some radio and phonograph manufacturers tried to integrate this style into their advertising art. Vincennes’ 1927 phonograph ads used a Picasso-like style to announce that they were “the spirit of modern music” (see Fig. 15a). Eduard Buk Ulreich (1889–1962) created a series of 19 abstract paintings for Victor’s Red Seal Records that were meant to interpret the musical pieces included in Victor’s portfolio. His vision of Scheherazade is illustrated in Fig. 15b.

16. Sporting Events

Radio was able to give sports fans something they never had before—a way to keep up with their favorite teams in “real time.” Manufacturers took advantage of magazine ad space to reinforce the idea that listening to the radio was almost the same as actually being in the sports stadium. Ads from Stewart Warner (Fig. 16a) and Philco (Fig. 16b) demonstrate how they used the popularity of sports to entice consumers to buy their products. Accessory manufacturers also cashed in on the sports theme to promote

their products, as shown by an example for Cunningham tubes in Fig. 16c.

17. Artistic Photographs

Photography was selectively used as early as the 1920s as a substitute for illustration art. By the late 1930s, with advances in halftone printing technology, photography became more cost-effective than illustrations. Nevertheless, photographers who were capable of very creative photo work, as it relates to this subject, were rare.

One very creative and noteworthy ad emerged in the late 60s for Philco’s cutting-edge CD-size Hip Pocket records. Their advertisement reproduced in Fig. 17a did not show them being played on a record player, but instead—of all things—as earrings. Clearly, they were thinking “outside the box.” These ads were aimed squarely at the teen market and they appeared almost exclusively in teen oriented magazines such as *Seventeen* and *Co-Ed*.

In 1964, Doyle Dane Bernbach (DDB), the ad agency used by Volkswagen to create their iconic minimalist ads, was retained by Akio Morita, the co-founder of Sony, to create a new revitalized advertising strategy.⁸ DDB’s small group of very creative copywriters, art directors, and photographers regularly took risks and were accustomed to thinking outside the box. One of their most famous ads for the 7” portable transistor TV titled “The Sun Set” (Fig. 17b) was featured in the *Art Directors Annual* for 1966, a compendium of the best ads of the year as voted by their peers.

According to the 80s Gallery’s web site,⁹ Manuel Nunez, an artist based

in Los Angeles, created about ten different artistic variations of the theme “eyes without a face” for Pioneer’s automobile radio advertisements from 1986 to 1988. In these dramatic ads Pioneer tried to show that their products were more sophisticated than those of their competition (see Fig. 17c).

18. Clever Headlines

Thanks to the creative genius of ad agency DDB, Sony’s magazine ads for their transistorized televisions were always attention getters. Bold headlines worked closely with the ad photo to create a humorous and eyebrow-raising experience. This campaign extended from late 1964 into the early 1970s.

Typical examples of this strategy are shown in the accompanying figures with the following taglines: “The Sun Set for Shut-ins” (Fig. 18a) and “A washday miracle.” Some do not require a picture to imagine what the point is, such as: “The clock radio that wakes you just like your mother did.” And my personal favorite for Sony’s super-quiet cassette recorders/players: “Kiss your hiss goodbye.”

Panasonic was known for creating some of the most novel radios and TVs ever produced during the early 1970s. For the most part, their advertising campaigns were rather lackluster, but there are a few notable exceptions. The ad for their UFO-like flying saucer shaped TV (model TR-005) had the bold caption: “Attention, Earth People.”

Another clever Panasonic ad took inspiration from the infamous beach scene in the movie “From Here to Eternity” starring Burt Lancaster and

Deborah Kerr. They pictured a couple kissing behind their portable AM/FM cassette recorder above the words “Hear to Eternity (see Fig. 18b). This Panasonic with auto-reverse lets the music go on forever.”

19. Double Entendres

Double entendres? Not much needs to be said here. The text is innocuous, but when matched with its respective ad layouts, well . . . you can decide if there was really a secondary message. Here are two examples: “What a chassis” (see Fig. 19a) and “Paired for top performance” (see Fig. 19b).

20. Sexy, Naughty, and Risqué

Some manufacturers were not content with the subtlety of a double entendre. Occasionally a few pushed the boundaries. One might expect Hugh Hefner to run naughty ads in *Playboy*. One may also be shocked to know that risqué ads first appeared in 1928 in *Talking Machine World* and *Radio Retailing*, placed by Utah Radio Company (see Fig. 20a). This strategy is reminiscent of Rigid Tools’ ubiquitous calendars that appeared on the walls of auto repair shops in the 1940s and 50s.

Stereo receiver manufacturers became even more brazen in the second half of the 20th century as the “sexual revolution” took hold, and magazines such as *Playboy*, *Esquire*, and *Penthouse* appeared everywhere. Altec-Lansing appears to have taken a page from Utah’s playbook in creating their sexy 1977 speaker ad (see Fig. 20b). It did not appear in *Playboy*, as one might have guessed, but in

Stereo Review. Near the bottom in tiny print is the following poetry: "Alone with the sea sounds and sunlight/the senses are freely touched/And whatever touches the senses/touches the soul."

Bell and Howell's "sound machine" ad cleverly captures the reader's attention (see Fig. 20c). Some may even notice the transistor radio. "Live and Let Live," Koss's theme for their headphone ads, took a more lighthearted approach (see Fig. 20d). The seemingly "ditzy" woman in the foreground appears to steal the show and, arguably, a great deal of the reader's attention.

Finale

Where else does art, history, science, technology, and entertainment all come together for viewing such small packages? Perhaps a quote from the cover notes of the book *20s: All-American Ads* sums it up best: "The ads do more than advertise products—they provide a record of American everyday life of a bygone era in a way that nothing else can."¹⁰

Endnotes

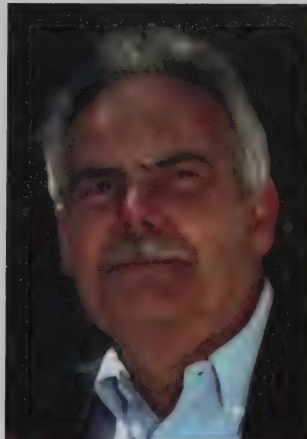
1. Thomas W. Volek, *Examining Radio Receiver Technology Through Magazine Advertising in the 1920s and 1930s*, University of Minnesota, 1990.
2. Barbara Havranek, "Radio Advertisement and Fashion," *AWA Review*, 2005, p. 65–100.
3. W. L. Larned, *Advertisement Illustration*, McGraw-Hill, 1929.
4. Donald Robert Stoltz and Marshall Louis Stoltz, *Advertising World of Norman Rockwell*, Crown, 1986.
5. Did Capehart really believe that a substantial number of Americans would be using the proceeds from their redeemed war bonds to buy an airplane?
6. "Suitable for Framing," Russell Lynes, *Harpers*, February 1946, pp.162–169; "Patrons at

a Profit—Business Discovers Art as a Selling Force," *Art Digest*, May 1, 1943, pp. 5,17.

7. Jacqui Morgan (1939–2013), born Jacquelyn Morganstern in New York, was an American illustrator, educator, and watercolor painter. She became influential during the 1960s and 1970s with the youthful and psychedelic style of her illustrations; https://en.wikipedia.org/wiki/Jacqui_Morgan.
8. Nick Lyons, "The Tummy Television and Other Bold Anachronisms in America," *The Sony Vision*, Crown, 1976, pp. 110–129.
9. 80s Gallery web site, <http://blog.the80sgallery.com>.
10. Jim Heimann (ed.), *20s: All American Ads*, Tashen GmbH, 2004.

About the Author

John Okolowicz has been dabbling with radios most of his life and is currently fascinated by the artistry of old magazine ads as they relate to consumer technology. He is a retired Honeywell engineer after working there for 29 years. For nearly 20 years he also sold reproduction grille cloth online. He has had previous articles published in *Radio Age*, the Mid-Atlantic Radio Club's newsletter, and *Antique Radio Classified*.



John Okolowicz

For Everybody's Christmas—

All the world is Broadway now! Every farm kitchen is a box at the opera. Every little city apartment is a grandstand seat for a hundred great events. Christmas this year will mean more than Christmas ever meant before! People everywhere will be tuning in on the action of the world—listening in to the theatres—the colleges—the churches—the big events happening—the big games being played. Some like the fun. Some like the music. Some the lectures. Everybody wants it all—loud and clear—tuned in at the turn of a knob—real as being on the spot. With a Radiola.

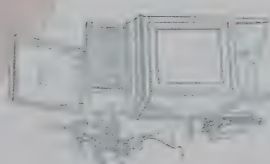
To get biggest performance look for the RCA mark and the name Radiola.

RADIO CORPORATION OF AMERICA

330 Broadway, New York. Sales Offices: Boston, 100 Park St.; Chicago, 116 La Salle St.; New York, 100 Broadway St.



The sound of music
in your home.



Radiola Grand
with automatic control device
for changing stations—no need
for manual tuning.
\$35.00

Radiola IV
with automatic control device
for changing stations—no need
for manual tuning.
\$29.50

© Radio Corporation of America, Inc., 1923.



Radiola Standard
the outstanding new
table model—easy to
carry, with a large
speaker. Model W-11
Radiola Standard
\$29.50
Radiola Standard
\$29.50

Radiola II
is a portable set
with a large speaker
and a large antenna.
It is the best set for
the home. All the
features of the Standard
model. \$29.50

Radiola V
is a portable set
with a large speaker
and a large antenna.
It is the best set for
the home. All the
features of the Standard
model. \$29.50



Radiola

REG. U.S. PAT. OFF.

Fig. 1b. RCA ad picturing a grandma and grandson. (Saturday Evening Post, Dec. 15, 1923, p. 72)



"Don't Cry Mother... It's Only A Program!"

Our constant laughter is worth it. It's the people in it! Mother's tears and smiles are the natural result of the laughter and fun that neighbor's everyday problems.

She shares the heartbreak of a girl who is humiliated of miles away—yet, further than distance itself, to the of her General Electric Radio, every program is there, seeing neighbors on the other side of the dial.

When a wonderful thing, this radio set for magic com- pany people, nations, cities and keeps right out of the picture—bringing colorful people to call this becomes what

finishes than the folks meet show. Summertime interesting hours that once were empty and lonely for an many of us brings counterblast of radiant color to we're the picture of gay days.

The new General Electric Radio is also different, each, realistic reproduction that every word and sound sweeps in with full depth and color. It's almost like another dimension in radio. And, interesting to when it comes to you via the radio, great fun of the new General Electric Radio.

General improvements are constantly being made in G.E. Radios. G.E. engineers have perfected a new Beam- Radio, plays with an important part in your daily life that you should enjoy it at its best. You can, for G.E. when it comes to you via the radio, great fun of the new General Electric Radio.

GENERAL ELECTRIC RADIO

LISTEN TO THE GOLDEN TONE OF GENERAL ELECTRIC

Fig. 1c. GE ad picturing mother crying while listening to soap opera. (Sat- urday Evening Post, Mar. 23, 1940)

THE SATURDAY EVENING POST

Enchanted lands...right in your home

No dream-land magic carpet ever journeyed through more wonderful realms... of freedom as far as fun. There's a world of inspiration in television. And the Dumont television set is the key to it. It's the most complete entertainment built with guide to be owned with guide. The new Dumont electronic advances in hand-colored radiants, incorporate the latest Dumont electronic advances from the laboratories that introduced television to America. They offer you the ultimate in television enjoyment. A complete line of sound, combination, table models.

DUMONT

First with the finest in television

For more information, write to: Mr. H. H. Moore, 140 N. 17th Street, New York 14, N.Y. or Mr. J. H. Moore, 140 N. 17th Street, New York 14, N.Y. or Mr. J. H. Moore, 140 N. 17th Street, New York 14, N.Y.

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Fig. 1d. Dumont ad by Norman Rockwell picturing children. (Saturday Evening Post, Dec. 9, 1950)

Melodies of an older and more gracious day . . . songs that span a lifetime of devotion, yet remain forever young . . . radio travels down the trail of memories on Mother's Day! "Old Folks at Home" . . . "Mother o'Mine" . . . "Bahm's" "Cadle Song" . . . simple tunes of home and mother-love which form a priceless musical heritage . . . are brought into your home with heart-warming realism by Philco. Through Philco High-Fidelity reception the programs of Mother's Day and all that radio offers throughout the year reaches the mothers of America . . . and their families . . . as if the artists were in the living-room! John Charles Thomas signs off with his never-forgotten "Goodnight, Mother!" The Philco which captures the tenderest moods reproduces the forisimos of a Marine Band march with the same true-to-life quality . . . floods your home with the rhythmic dance music of Guy Lombardo . . . or brings programs from Paris . . . Rome . . . London . . . and other foreign cities!



The most important step forward in radio this year—the Philco *Auto-Tuning* System, which automatically tunes the aerial as you tune the set. A Philco discovery that doubles the number of stations you can hear and makes them sound as if they were right next to you in price. And only Philco has it! See the classic telephone directory for your nearest dealer and have a demonstration. Sold on the Philco Commercial Credit Time Payment Plan.



PHILCO
A Musical Instrument of Quality

PHILCO REPLACEMENT TUBES IMPROVE THE PERFORMANCE OF ANY RADIO . . . SPECIFY A PHILCO FOR YOUR AUTOMOBILE

THE NEW PHILCO 116X

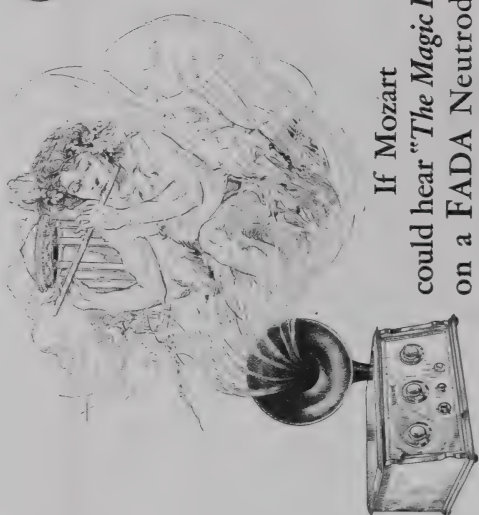
A true high-fidelity instrument bringing into the overtones that beauty and distinction of the many and varied musical forms. It is the only radio that can reproduce the full range of the human voice, the finest sounding record, every note up to your ear level. Five wave bands bring you every broadcast service in the air . . . from the most popular to the most exclusive. With orchestra, symphony, *Auto-Tuning* System, \$160

EVERY product guaranteed as advertised—see page 6

HQ

THE SATURDAY EVENING POST

March 7, 1932



If Mozart could hear "The Magic Flute" on a FADA Neurodyne

—his trained ear would approve the tonal fidelity to the original in his famous old opera. The peculiar charm of this woodland instrument is caught in all its purity by the famous FADA Neurodyne. With equal truth, FADA reproduces the deep rolling bass of the pipe-organ.

The FADA Neurodyne has the range of the 88-key pianoforte, McCormack's pure tenor, Boy's delicious soprano, create the illusion of standing beside the actual

artists when you hear them on a FADA set. Bass and baritone voices are reproduced with equal fidelity. There are six models to meet every taste and pocketbook. \$75 to \$270. FADA is adapted to either dry-cell or storage-battery tubes, and either indoor or outdoor aerial.

Hear FADA. It will be a revelation in radio! Buy your FADA now and be ready to hear the world's famous artists whenever they sing or play for you over the radio.

F. A. D. ANDREA, INC.
1311 ADOBE AVENUE
NEW YORK



FADA
R a d i o

Fig. 3a. Philco ad created in pen and ink. (Good Housekeeping, May 1936, p. 5)

Fig. 3b. Fada ad created in pen and ink. (Saturday Evening Post, Mar. 7, 1925, p. 160)

Study the Circle!

by official figures, it proves
the *overwhelming public preference*
for FREED-EISEMANN

One of last year's confusion in radio, this one has cleared up. Through popular demand, FREED-EISEMANN has become the standard.

Although competing, in the "Standard" field alone, with eleven other licensed manufacturers, FREED-EISEMANN has become the largest and most successful manufacturer of the kind in the world.

Why the irresistible trend towards this one radio set?
The organization was one of the pioneers in radio. Even before the days of general household ownership, it was the first to make a radio set an important factor in buying about the home. It was the first to make a radio set an important factor in buying about the home.

Because of the superb engineering and construction of the FREED-EISEMANN, you can be sure that your set, clear here is an instrument made with a feeling of personal responsibility. Rightly do you feel, therefore, that you are buying a radio set that will give you the best of the best.

Freud-Eisemann!
FREED-EISEMANN RADIO CORPORATION
MANHATTAN BUILDING, 1424, BROOKLYN, N. Y.

adjustments are those of Siemens. And its greatest is the fact that it has been constructed for the purpose of being a radio set that will give you the best of the best.

compared, FREED-EISEMANN and among the first of the great pioneers.

who made the world larger for all men, among the first of the great pioneers.

who made the world larger for all men, among the first of the great pioneers.

who made the world larger for all men, among the first of the great pioneers.

who made the world larger for all men, among the first of the great pioneers.

who made the world larger for all men, among the first of the great pioneers.

who made the world larger for all men, among the first of the great pioneers.

who made the world larger for all men, among the first of the great pioneers.

who made the world larger for all men, among the first of the great pioneers.



EISEMANN
IN RADIO

The Eisemann Radio Set is the most complete and reliable radio set ever made. It is the only radio set that will give you the best of the best.

Fig. 3c. Freed-Eisemann ad in two colors with pen & ink. (Saturday Evening Post, Oct. 24, 1925, p. 132)



Fig. 4b. Brandes impressionist art speaker ad. (*The Sphere*, Nov. 22, 1926, p. 51)



Fig. 4a. RCA ad drawn by Everett Shinn (*Country Life*, Aug. 1926, p. 93)

In the Dark of the Hour



Like a storm, unfolded moments of disappointment sweep into the heart of man. Dreams once known are vanished. A shadow is on the sun.

Yet this may be a mood, and moods can change. The glorious voice of the Capehart Phonograph-Radio can bring new inspiration to the darkened hour. The exultant chorale, the symphony, the melodic surge of the tone-poem, interpreted by the Capehart, offer fresh courage in a world of tumult and war.

The building of the Capehart has ceased, and the research laboratories and vast plants of the Farnsworth Television & Radio Corporation are engaged solely in war production. Unless you now own a Capehart, or purchase one still remaining in dealers' showrooms, you must wait until victory to enjoy this superlative instrument.

But you can prepare for the war's earlier end by buying War Bonds! Your country needs your investment, and

you will be building soundly for the future, when you may want to purchase a home, a car, an airplane, a television set, or a Capehart.

Meanwhile, your Capehart dealer offers you counsel on all your musical requirements, including the selection of a piano, an organ, band and orchestra instruments, sheet music and the latest recordings. . . . The Capehart Division of the Farnsworth Television & Radio Corporation, Ft. Wayne, Ind.

"The Engulfed Cathedral," by Claude Debussy, painted for the Capehart Collection by Raymond Breinin. In this rich, impressionistic tone-poem, the French composer tells the ancient Breton legend of the cathedral which, at certain seasons, rises in tidal splendor from the sea.

Reprints of previous paintings in the Capehart Collection, suitable for framing, are now available from your Capehart dealer at a modest charge. Or write direct to the Capehart Division.

Capehart Early Gramophones, with the time-proved record changer that turns the records over. The Capehart is equipped for FM radio reception.

CAPEHART - PANAMUSE - FARNSWORTH

GREAT NAMES IN ELECTRONICS—MUSICAL REPRODUCTION—TELEVISION

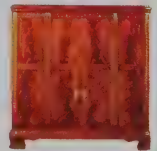


Fig. 4c. Capehart ad "The Engulfed Cathedral" by Breinin. (*Life*, Nov. 16, 1942, p. 30)

Had van Gogh owned a Fisher, he might have thought twice.

Before the turn of the century the human ear wasn't accorded the respect it is today. Then two rather important developments came to pass.

First, conversation grew more intelligent. Next a fellow by the name of Avery Fisher assembled the world's first high-fidelity audio system.

That system, for your information, now resides in the Smithsonian. But the ingenuity that landed it there can easily be found today—in a complete line of Fisher audio component systems that are designed to fit any kind of room. And every kind of budget.

The Fisher trademark is a system that performs flawlessly as a unit—not by some quirk of fate, but by precise and deliberate planning.

As you might imagine, delivering that level of performance demands our taking some extraordinary measures.

Like refusing to compromise. In fact, the Fisher standard of quality is enforced relentlessly for every component, at every stage of its development.

Of course, we're only human. But at Fisher, we've always considered that our greatest resource. Our keen sense of ergonomics was developed long before the word came into vogue. That's something you'll appreciate in the placement of every control. In the feel of every button or slider. And in the features we've thought to provide.

Just look at our System 8855D. Its five-disc CD changer technology wasn't developed merely to please lab test equipment (though it does, handily). It was designed to please the human ear—and human nature—with such features as introscan and random programming. The system includes a double cassette

deck with high-speed dubbing and a semi-automatic turntable. Which, along with the CD, are integrated with a 14-band graphic equalizer to customize the sound to your exact environment.

As for amplification, the system offers enormous power—150 watts per channel. But every bit as important, we've given it speakers (with 15-inch woofers) that are up to the challenge.

Our System 8855D also offers Dolby® Surround Sound, allowing you to experience music as if you were sitting in a stadium or concert hall.

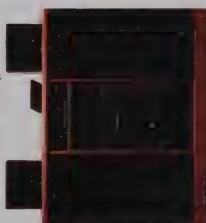
It even comes with a programmable remote control that can learn hundreds of commands for just about any remote-controlled component. So you can change your music or video as easily as you change your mind.

But at this point it's best to concentrate on making up your mind.

So we suggest an ear-opening visit to your nearest authorized Fisher dealer.

The sound alone should convince you to choose a Fisher system.

Without a second thought.



FISHER.



Fig. 4d. Fisher's ad using Van Gogh's artwork. (*Esquire*, Dec. 1988, p. 52)

When you seek the
Christmas Path to any heart—



Crosley
Model 85
12-inch \$49.75
16-inch \$64.75
T&E Table Model
\$79.50

"You're there with a Crosley"

CHANCE! America's new income tax law has made it possible for you to get a full radio! Here is the reason: The Government has performed so amazingly that an enthusiastic country-wide acceptance has traveled the country. Such success is not only commendable, when you see what goes into the set and realize what stands behind it, but it is also a development amplified and augmented by the resources and research activities of the General Electric Co., The Westinghouse Co., and the Radio Corporation of America.

Some Co., The American Telephone & Telegraph Co., and The International Telephone & Telegraph Co. have joined in the effort to make a radio set that is not only a pleasure to use, but also a practical one. Under such conditions, the Government's acceptance has traveled the country. Such success is not only commendable, when you see what goes into the set and realize what stands behind it, but it is also a development amplified and augmented by the resources and research activities of the General Electric Co., The Westinghouse Co., and the Radio Corporation of America.

radios are equipped with a variety of features that make them a real home companion. Not only are they portable, but they are also a real home companion. Not only are they portable, but they are also a real home companion. Not only are they portable, but they are also a real home companion.

CROSLLEY RADIO CORPORATION
The Crosley Radio Corporation is a new and growing company, which is now producing a line of radios that are not only a pleasure to use, but also a practical one. The Crosley Radio Corporation is a new and growing company, which is now producing a line of radios that are not only a pleasure to use, but also a practical one.



The Crosley
BANDBOX
Radio Receiver
\$55
A.C. Model 85

Fig. 5a. "You're There With a Crosley" ad. (Liberty, Dec. 3, 1927)

Fig. 5c. "Meet Your New Neighbor" ad with a Hallicrafters radio. (*Fortune*, July 1944, p. 20)

NO SQUAT NO STOOP





NO SQUINT



..with the 1938
AUTOMATIC TUNING
PHILCO

**New, Easier
Terms at all
Philco Dealers**

Fill in and mail
this coupon **at once!**

SPECIAL OFFER COUPON

Name _____
Address _____
City _____ State _____
Zip _____
Phone _____
I am interested in the new Double-X Philco
radio and would like to know more about it.
Please send me a copy of the new Double-X Philco
radio catalog and a copy of the new Double-X Philco
radio manual.

**Radio
marches on!**

For today... and for the future... Philco presents the latest in radio... the new Double-X Philco radio.

With up-to-the-minute 1938 Philco 1188K, with its new Double-X Philco radio, you can enjoy the best in radio... the new Double-X Philco radio.

Philco brings every inch up to your ear level... the new Double-X Philco radio.

Be sure to ask your dealer to show you the new Double-X Philco radio.

Philco's new... the new Double-X Philco radio.

Philco's new... the new Double-X Philco radio.

Philco's new... the new Double-X Philco radio.

Philco's new... the new Double-X Philco radio.

Fig. 5b. Philco's first "no squat, no stoop" ad. (*Philadelphia Inquirer*, Aug. 8, 1937, p. 13)

FRESH FROM MOTOROLA... *new leader in the lively art of electronics*



Stylish for people who like informal living, this Motorola TV/Stereo combination in a compact cabinet less than 4' wide offers as handsome a bit of Early American charm as the eagle on the wall.

**Motorola makes it easy to choose
the TV that's right for you**

If you're shopping for a new TV set here are two good questions to ask yourself: Does it have a dependable classic? Will it fit in comfortably with the rest of my furniture?

Motorola makes it easy to get an affirmative answer on both counts. In the first place, every

Motorola® TV has a hand-wired chassis that's precision crafted for long life with modern hand and hip soldering methods. This extra bit of care has proved so effective that even Motorola TV set


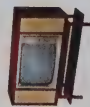
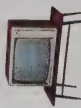
When it comes to selecting a TV set to fit in with your other nice things, Motorola bids you carries a full year written guarantee.

there, too. You'll see such a wide variety of models and styles, you're almost sure to find the one that's right for you. There are portables as low as \$400, consoles starting at \$299.95. TVs start at

4-5 combinations from \$320.95. All prices shown are manufacturer's suggested list options.

For TV you can live with happily... see your Motorola dealer. You can choose Early American, Contemporary, or Traditional styling. And many

models feature exclusive Motorola cabinetry taken from the luxurious furniture groupings of Dressel and Heritage.


MOTOROLA

For do-it-yourselfers, the compact Motorola MC6000, with its 100-watt power amp, allows you to connect the TV with a portable cassette or a turntable. Less than \$200.00. Motorola dealers.

For do-it-yourself decorators a compact Motorola TV that moves from table, to bench, to stack-on-shelf, allows never ending flexibility to decorate. **Model:** 25T502.

Plus than who like
ance of vent, trims
TV in fresh, crisp
in beautifully with
business. \$199.95.

Being 'king of the mountain' is a grown-up reality for this young couple. Their contemporary cliff house, hung around a solid rock pinnacle, gives them a commanding view of both the village and the sea below. Point of interest: the Nikola Tesla Hi-Fi combination with VNE AM and FM stereo radio is called Walnut cabaret from the Drexel collection grouping.

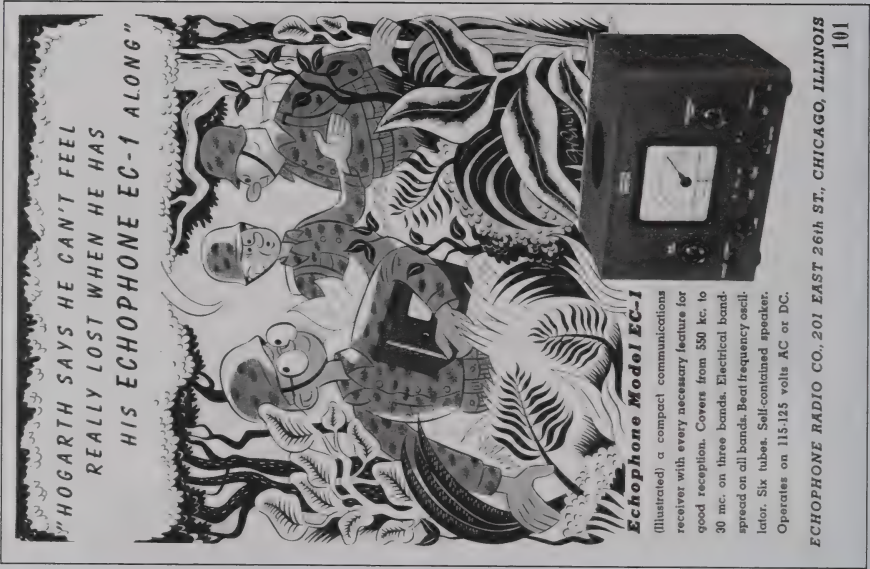


Fig. 6b. Echophone comic ad featuring Hogarth. (OST, Nov. 1943, p.101)



Fig. 6a. RCA Radiotron comic art by Rea Irvin. (Radio News, Oct. 1925, back cover)



This Philco Apparente Radio Phonograph...

brings you the sensational Philco Advanced FM System,
the amazing *Electric Dynamic Response*... *lighting* *electronic*
development that brings *stunning* *new power and*
performance, the most *glorious* *tone* you have ever enjoyed
from *radio and recorded music*. Your Philco dealer has it now.

PHILCO *Forever for Quality in World Class*

Fig. 7a. A Philco noir-style ad. (Time, June 2, 1947, p. 21)

announcing a new world of sound...

1959 ADMIRAL DUAL CHANNEL STEREO HIGH FIDELITY
AWARD-WINNING DESIGN! SPACE SAVING T-CABINET ENSEMBLES!

An historic first! All 1959 Admiral Dual Channel Stereo High Fidelity Phonographs are now available in a new, more compact design. Space saving, yet still giving you the same superb high fidelity sound better, too!

*As easy to play as any other phonograph, but what a wonderful world of difference in what you heard! The difference is in the sound. The sound of two mind *apart*. Bright speakers! Incomparably better than single system sets. The new Admiral Stereo sound now at your Admiral dealer.*

Also, the other Model 474, Master Tone High Fidelity PHAM, Canada, with matching Stereo High Fidelity Phonograph, is available in a new, more compact design. Space saving, yet still giving you the same superb high fidelity sound better, too!

Choose from cabinets that won the Hall of Fame Award for design.

MARK OF QUALITY Admiral®
THROUGHOUT THE WORLD

The Imperial Model 474, Complete, all-in-one Stereo High Fidelity PHAM with exclusive T-cabinet, space-saving answer to your demanding demand.

BOLD IN 90 COUNTRIES... MANUFACTURED IN U.S.A., ARGENTINA, AUSTRALIA, BRAZIL, CANADA, ITALY, MEXICO, PHILIPPINES, AND URUGUAY

Fig. 7b. Admiral ad using a dark background. (New Yorker, May 2, 1959, p. 156)



"BEHIND THE SCENES" AT A COUNTRY CLUB

A batch of once prominent members of New York Society, the last day around — in their moment — had their picture actually secured on a country club. They were long-haired, and the picture was taken in a very high school. . . . But, when both of them were shown, the picture was taken, of course, in the same manner. (The picture was taken, of course, in the same manner.)

Copyright © 1929, by Peter Arno

Copyright © 1929, by Peter Arno

Fig. 8a. Kolster's subtle ad in a country club setting. (Vogue, July 6, 1929, p. 97)



GOLD-DIGGER:

"I have an artistic soul, too. I love good music."

SUGAR-DADDY:

"Well, little gal, don't cry, I'll see what I can do. They're in kinder big demand but I'll get you one of those Kolster Radios somehow."

COMMANDER BYRD selected Kolster Radio and Kolster Radio Company for the only place where he could find a Radio for his wife and children. (The Radio for his wife and children.)

Advertisement

Copyright © 1929, by Peter Arno

Fig. 8b. Kolster's subtle ad by cartoonist Peter Arno. (New Yorker, Nov. 24, 1928, p. 47)



Fig. 9a. Sparton poster-style ad with female guitarist. (*Liberty*, Sept. 7, 1929, p. 15)



Fig. 9b. Marantz "Slays Foul Sound" poster ad. (*Rolling Stone*, Sept. 7, 1978, back cover)



With Sansui you are right on. Sansui engineering provides a series of four-channel receivers that are enough ahead of their time to put the future in your hands, now. The unique Sansui QS vario matrix gives you richer, fuller four-channel sound from QS (Regular Matrix) as well as SQ (Phase Matrix) sources, plus de-modulated CD-4 and discrete tape. With its superior QS synthesizing section, it creates realistic four-channel sound from conventional stereo. Control your future with the QRX-6500, 5500, 3500, or 3000. Hear them at your franchised Sansui dealer.

**who controls
your four-channel destiny?**

QS
REGULAR MATRIX

Sansui

SANSUI ELECTRONICS CORP.
Woodside, New York 11377 • Gardena, California 90247
SANSUI ELECTRIC CO., LTD., Tokyo, Japan
SANSUI AUDIO EUROPE S. A., Antwerp, Belgium • ELECTRONIC DISTRIBUTORS (Canada)

CIRCLE NO. 48 ON READER SERVICE CARD

Fig. 9c. Sansui's psychedelic-style poster. (*Stereo Review*, Nov. 1973, p. 7)

2

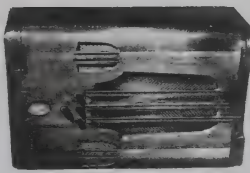
*** IMPORTANT! To open coasts you need a specifically designed aerial. Install a Pilco All-wave 8 relay to and throughout this powerful 115V is capable of driving.**

PHILCO REPLACEMENT TUBES IMPROVE THE PERFORMANCE OF ANY RADIO LISTEN TO BOAKE CARTER OVER KEY COLUMBIA STATIONS SPECIFY A PHILCO FOR YOUR AUTOMOBILE



April 18th, 1775, British troops march out of Boston to destroy the arms and munitions in the hands of the Patriots, Paul Revere idling to arouse the "overly Middlesex village and farm." Next day the bandful who received the warning fired "the shot heard round the world"—starting the struggle which gave America its freedom. Today, in an emergency, we would find a warning over the whole country in less time than it took Paul Revere to awaken one townsmen. Great has been the progress of science and invention!

(The illustration is from a painting by John Trumbull, "The Minute Men, the State House, Boston, Massachusetts.")



NEW PHILCO 116X... \$179.⁰⁰
WITH PHILCO ALL-WAVE ANTENNA... \$89.

THIS new Philco is a true Big-Boy Fidelity Instrument with vastly extended musical range bringing you the overtones which identify instruments, the mellow and varied musical timbres... NEW and exclusive Acoustic Chorus automatically prevents unpleasant distortion by the "A2S" effect... The new Philco 116X has the clarity of air at the extended musical range of all the extended musical range of Philco Big-Boys are guaranteed and projected up to sea level by the large area and slope of the famous Philco Inclined Sounding Board... IN addition, the 116X gives you Precision Control over every broadcast service on the Air—Foreign as well as American Stations, All Police, Amateur, Ship, Aircraft and U. S. Government Weather Forecast Stations.

Paul Revere could have stayed in bed



KCA LABORATORIES — fountain-head of radio progress

From its inception, RCA has held that research is the one true way of advancing in radio. RCA Laboratories therefore are organized as well as the development of new products and new applications of known products. The RCA Laboratories are a part of an ever-growing radio industry that is a part of a new hope for a system on the airwaves.

RCA continues the radio research and will continue to do so because it believes that radio, as an art of accomplishment, has only reached the summit of an ultimate possibility. For the maximum development of these possibilities RCA is dedicating

Radio could have reached "every Middlesex village and farm" before the famous silversmith got started

Today, matters of importance, whether to nations or to individuals, are fleshed out around the world instantly. R.C.A. Communications provides communications to and from 43 countries and among leading cities of the United States.

RCA services and RCA equipment put RCA's service in many other ways. Broadband programs provide an increasing flow of entertainment, offer information, news and enlightenment, tell stories. Airlines and entertainment officials, Air-

planes fly more safely, are guided more surely to their destinations, by radio. Radio plays a vital role in the plans of the Army and Navy for national defense.

RCA activities are portrayed in RCA exhibits at the New York World's Fair and the San Francisco Exposition. You are cordially invited to visit these exhibits.



RADIO CORPORATION OF AMERICA
RADIO CITY, NEW YORK

RCA Manufacturing Company, Inc. • RCA Laboratories
National Broadcasting Company • Radio-Communications Corporation of America • RCA Communications, Inc. • RCA Institutes, Inc.

Fig. 10a. Philco ad referencing Paul Revere's ride. (*American Magazine*, Sept. 1935, p. 73)

Fig. 10b. RCA ad featuring Paul Revere. (*Life*, Sept. 25, 1939, p. 97)



E. F. McDONALD, JR.
President, ZENITH RADIO CORPORATION, says:



Look for this mark
on every Radiotron

"We determine the performance of all of our receiving sets by using RCA Radiotrons. That is because they materially enhance the reception of our instruments. We urge our dealers to recommend them for initial equipment and for replacement."

E. F. McDonald, Jr.

If you wish your receiving set to give you the best results, renew all of your vacuum tubes with RCA Radiotrons once a year at least. It is better not to use new tubes with old ones.

RCA RADIOTRON

RADIO CORPORATION OF AMERICA , New York , Chicago , Atlanta , Dallas , San Francisco

Fig. 11a. RCA Radiotron ad crossbranding Zenith radio featuring E. F. MacDonald. (*Saturday Evening Post*, Feb. 16, 1929)

A painting of a man in a yellow raincoat, holding a small clock. The background features a larger clock on the wall and various objects like a lamp and a vase. The style is expressive and somewhat abstract, with a dark, thick border around the scene.

Masterpiece of entertainment **RCA VICTOR** "Pockette" Personal Radio

Small size, but big performance—that's the all-new, all-transistor portable radio by RCA Victor! Exclusive "High-T" Circuit broadens tonal response, improves fidelity. Allows extended peak performance with up to 2½ times longer battery life without distortion and fade-out! Non-breakable "Impac" Case Guaranteed for five years. Designed to fit neatly in the pocket of your Marlboro "Pocket" shirt. See the "Pocket" radio at your RCA Victor dealer.

The Most Trusted Name in Sound


**RESUME** : *Novembre*

010

From the land of the masters and the hand of the masters... Vermeer

marlboro

SABENA *Le unica Belgica*



BELGIAN World AIRLINES

For your "Vermeer" shut, visit **Aluminium - Kistler Collister**, Baltimore - **Hochschild Kohn** and **CK & Wallin**, Birmingham - **Loveman's**, Cincinnati - **Mabley & Carey**, Columbus - **The Union Company**, New Orleans - **Maiton-Blanche**, New York - **Arnold Constable**, Omaha - **J. L. Brandeis & Co.** (OWARD), Brandon - **Samters**, and fine stores everywhere. **Marlboro** Short Co., Baltimore 1, Maryland

Source: November

2

Fig. 11b. RCA joint ad with Marlboro cigarettes. (*Esquire*, Nov. 1960, p. 180)



Philco's battery-powered Safari Portable TV and Van Heusen's style-powered leisurewear get together for the fun of it.

Never has the hunt for fun been catered to so well. This leisurewear has the robust styling and easy comfort you expect from Van Heusen. The fabrics—many “wash & wear”—are dedicated to your leisure. Whether you cast for trout or camp out, Safari does justice to the occasion. Shirts shown, \$4.00, except Olive shirt (center), \$5.00. Shorts, \$5.00. Deck pants and red shorts, \$5.95. Terry jacket, \$6.95.

VAN HEUSEN

Now, Philco's Safari lets you take your TV fun anywhere! It plays without plugging in. You enjoy a bright picture even in brilliant sunlight. Safari plays on its own rechargeable battery or AC house current. Weighs a scant 15½ pounds. Less than 17" tall, Safari is the world's first TV you can take on picnics, to the beach, on boats, truly anywhere! Rugged leather case, natural or black with saddle stitching. See Safari TV at your Philco dealers now! **PHILCO**

Fig. 11c. Van Heusen shirt ad featuring Philco's Safari TV. (*Esquire*, June 1960)



Fig. 13a. Admiral TV ad with fashion sketch art (American Weekly, March 4, 1951, p. 13)



Fig. 13b. Another Admiral TV ad using fashion art. (Colliers, May 26, 1951, p. 9)



Cabinet Phonograph

\$15

In the Far West - \$17.50
Dominion of Canada - 25.00
Australia - £6 6s

THE ALL-SEASON PHONOGRAPH

THE CAROLA in a very short time has won an amazing nation wide popularity. Its convenient light weight and size have helped to do it; its beauty of design and elegance of finish have helped too; its top, dustproof compartment for records and other exclusive features have helped, but the real reason is its marvelous interpretation of all standard disc records.

Weights but 11 pounds.

Cabinet made entirely of acoustic metal, with handsome mahogany finish.

Music does not pass thru metal, but thru violin fibre tone arm.

If you don't know the Carola dealer in town, write us for free demonstration in your home.

Size 11x13x22 inches, 31 inches high in playing position.

One winding of the sturdy motor plays one 12-inch or two 10-inch or three 8-inch records.

DEALERS: We have an exceptional opportunity for you. Good territory still open. Write for details.

THE CAROLA COMPANY, 513 Leader-News Building, Cleveland, Ohio

Fig. 14a. Carola phonograph ad drawn by Coles Phillips. (Metropolitan, Nov. 1916)

ATWATER KENT RADIO



The Receiving Set illustrated is the Atwater Kent Model 30. The Radio Speaker is Model H.

Here is Radio's greatest thrill—a touch of your finger tips and the ONE Dial finds anything on the air within range. No tuning—just selecting. Radio reduced to its simplest terms. That's the Atwater Kent ONE Dial Receiver. The world's largest radio factory stands behind it.

EVERY SUNDAY EVENING
The Atwater Kent Radio Artists bring you their summer program at 7:15 Eastern Daylight Time, 8-15 Central Daylight Time, through:

WEST . . .	New York	WCCO	Minneapolis	St. Paul
WELL . . .	Boston	WGBX	Chicago	
WASH . . .	Cincinnati	WCX	Buffalo	
WEST . . .	Washington	WJL	Detroit	

Send for illustrated booklet telling the complete story of Atwater Kent Radio.

Prices slightly higher west of the Rockies and in Canada.

ATWATER KENT MANUFACTURING CO.
Atwater Kent, Products
4704 Wissahickon Ave. • Philadelphia, Pa.

Fig. 14b: Atwater Kent ad drawn by McClelland Barclay. (*Literary Digest*, July 24, 1926)



Fig. 14d. Bendix radio ad stresses beauty. (*Woman's Home Companion*, Nov. 1947, p. 158)



Fig. 14c. Crosley's Glamor-Tone radio ad. (*Life*, July 15, 1940, p65)

The Spirit of Modern Music

Vincennes... unknown yesterday... today without peer... has glorified the Veraphonic principle catches the spirit of modern music. ♦ ♦ ♦ Reproduces as you have never heard it before. ♦ ♦ ♦ So far in advance of all known methods that music lovers unflinchingly select Vincennes on beauty of tone quality over any other instrument.



You will pick the Vincennes instrument

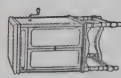


VANDALUSIA
The first instrument in the Vincennes line... Equipped with bronze fittings, auto-matic stop and unique drawers for records. ♦ ♦ ♦ Made in Rome. ♦ ♦ ♦ Specifically adapted to all models.



VENETIA

Refined or mahogany, bronze fittings, automatic stop, spring motor



The New Veraphonic
VINCENNES PHONOGRAPHS

Fig. 15a. Vincennes Phonograph uses Art-Deco style art. (World's Work, Oct. 1927)



The rich, mysterious music of the East...

SCHEHERAZADE speaks... It is a tale of marches, to beguile her lord. She tells of Sinbad and the magic isles... horses with barren feet, and men of steel... sultana and princesses, *hariz* and turbaned slaves. Color, warmth, rhythm, the very perfumes of the Orient breathe in her artful words.

From that ancient collection of tales known as the *Arabian Nights*, Rimsky-Korsakoff drew inspiration for some of the most vivid and exotic music ever written. His *Scheherazade* Suite is a marvelous arabesque of orchestral color, brilliantly imaginative, technically fine. Three generations of music-lovers have delighted in it. It should be in every musical library.

The *Scheherazade* Suite has been recorded by Leopold Stokowski and the Philadelphia Symphony Orchestra. It is available in a special album, with an explanatory booklet. In it, Victor's Orthophonic process has preserved both the full splendor of the music itself and the subtlety and vigor of its interpretation.

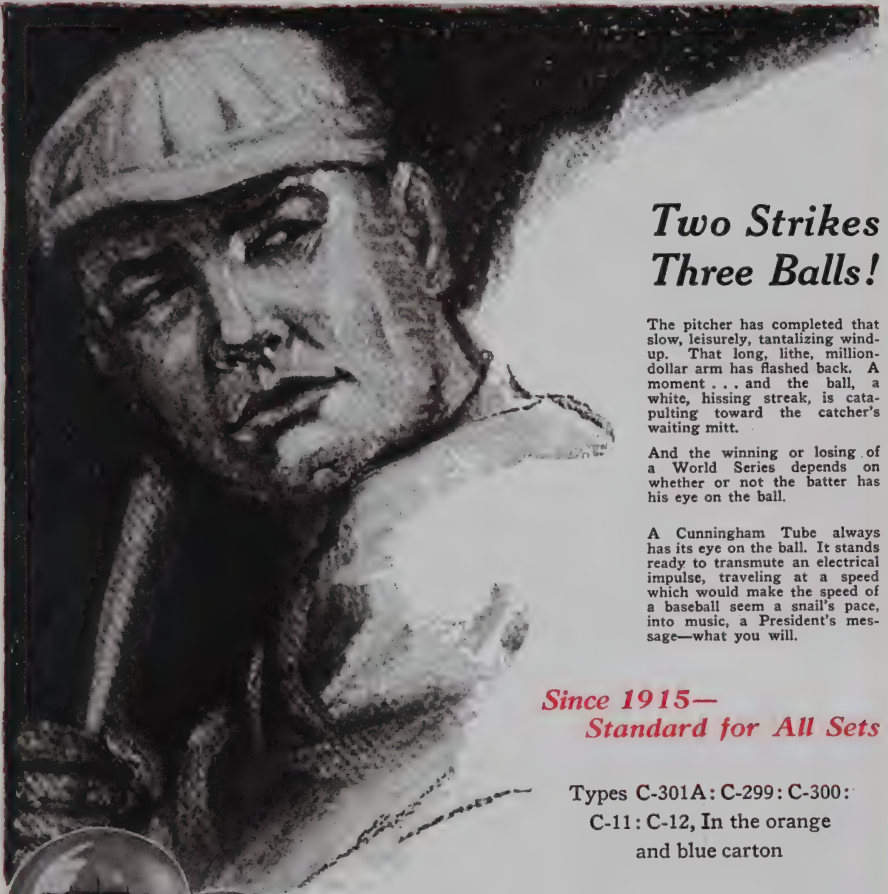
The nearest Victor dealer will gladly play you the *Scheherazade* Suite or any of the beautiful new Victor recordings, by the foremost artists and orchestras... Write today for the free illustrated booklet, "I Musical Galaxy," with foreword by Leopold Stokowski—a commentary upon one of the greatest moments in music.

Victor Talking Machine Company, Camden, N. J., U. S. A.

VICTOR Red Seal RECORDS



Fig. 15b. Victor Red Seal ad with artwork by Eduard Buk Ulreich. (Literary Digest, April 14, 1928, p. 45)



Two Strikes Three Balls!

The pitcher has completed that slow, leisurely, tantalizing wind-up. That long, lithe, million-dollar arm has flashed back. A moment . . . and the ball, a white, hissing streak, is catapulting toward the catcher's waiting mitt.

And the winning or losing of a World Series depends on whether or not the batter has his eye on the ball.

A Cunningham Tube always has its eye on the ball. It stands ready to transmute an electrical impulse, traveling at a speed which would make the speed of a baseball seem a snail's pace, into music, a President's message—what you will.

*Since 1915—
Standard for All Sets*

Types C-301A: C-299: C-300:
C-11: C-12, In the orange
and blue carton

Price \$3.00 each



Cunningham RADIO TUBES

Home Office:
132 Second Street,
SAN FRANCISCO

E. J. Cunningham, Inc.

NEW YORK
CHICAGO

Patent Notice: Cunningham tubes are covered by patents dated 2-19-06, 2-18-12, 12-30-13, 10-23-17, 10-23-17, and others issued and pending.

Fig. 16c. Cunningham also uses baseball to sell tubes. (*Radio News*, May 1925, p. 2)



Fig. 17b. Sony's award-winning photo ad for their TV. (*Life*, Sept. 16, 1966, p. 51)

Now you can carry your Hip Pocket Records on your ear.

Grooviest earrings ever. Hold up to twenty Hip Pocket Records. Just 50¢ at any participating dealer when you buy two HP's. (A top hit on each side; mini-priced; the most scratchproof records of all.) Of course, if you ever want to wear the earrings alone, you can always carry your Hip Pocket Records in your purse.

PHILCO

PHILCO ELECTRIC CO. • PHILCO MADE IN U.S.A.
The Story This Earphone is Told with Extra Details

COB • MARCH, 1968

Fig. 17a. Philco's clever earring ad for their Hip Pocket record system. (*Co-Ed*, Mar. 1968, p. 1)

**GIVE YOUR AMERICAN CAR
A DASH OF GOOD LOOKS.**

PIONEER

AUTO AMERICA™

PIONEER INTRODUCES THE MOST BEAUTIFUL STEREOS EVER DESIGNED FOR THE AMERICAN AUTOMOBILE.

Let's face it, you probably didn't buy your American car because you loved the stereo that came with it.

Which left you with only two choices. Either put up with that dashboard eyesore, or replace it with another unit that stuck out like a sore thumb. It was enough to drive you crazy.

That's why Pioneer proudly introduces their newest concept in car stereos—Auto America™.

Their sleek, futuristic styling and high-tech controls fit right in with today's American dashboards. And thanks to Pioneer's exclusive shaftless design, shorter mounting depth, and flush edge-to-edge fit, they won't stick out of your dash—or even worse, leave a hole in it.

As for the music they make, they're pure Pioneer, so you know you're getting the most beautiful sound on the road.

Auto America by Pioneer. The first car stereos you'll be proud to put in your American dash.

PIONEER

Auto America™ units available: RF-4000, RF-4000 Quick Release, RF-4000, RF-4000 Quick Release. Optional graphic equalizer, shock absorber also available. © 1988 Pioneer Electronics (USA) Inc., Long Beach, CA

Fig. 17c. Pioneer's artistic auto-radio ad by Manuel Nunez. (*Playboy*, June 1988, p. 138)



Hear to eternity.

This Panasonic with auto-reverse lets the music go on forever.

Now the end of the tape doesn't mean the end of the music. Because auto-reverse in this Platinum Series™ AM/FM stereo cassette recorder plays one side after another automatically. So your favorite music never has to stop at the end of the tape. With Panasonic's Automatic Ambiance™, you'll hear sound that surrounds you like ordinary stereo can't. Plus, four preset equalizers to tailor that sound just the way you want. And our two-way stereo speakers lift the magic of the music to new heights. For auto-reverse in a time-piece, listen to the great sounding Panasonic Platinum Plus. With features that rival your home system.

Panasonic with auto-reverse. So the moments never has to end.

Panasonic. Just slightly ahead of our time.

Fig. 18b. Panasonic "Hear to Eternity." (*Playboy*, Dec. 1985, p. 86)

The Sun Set for Shut-ins

Even the sun can't escape the shut-ins. For them, the sun is a distant memory. But with a Sony TV, the sun is always just a push of a button away. The Sony TV brings the sun's warmth and light into the home. So the shut-ins can enjoy the sun's rays all day long. The Sony TV is the perfect solution for the shut-ins. It's the only TV that can bring the sun's warmth and light into the home. So the shut-ins can enjoy the sun's rays all day long. The Sony TV is the perfect solution for the shut-ins. It's the only TV that can bring the sun's warmth and light into the home. So the shut-ins can enjoy the sun's rays all day long.



Fig. 18a. Sony's comic TV ad for "shut-ins" (*Life*, Nov. 24, 1967, p. 27)

What a chassis.

Not hers, ours. The CTC49, a 100% solid state color chassis designed for our new 110-degree color picture tube. A chassis with incredibly easy servicing.

With our new plug-in AccuCircuit modules, there's no matching of metal prongs. The AccuCircuit module is copper-etched on the edge to form "rugged" board-contained connectors. Matching the self-formed connectors to their respective receiver socket is easy. It's a snap. You don't have to worry about bending prongs out of shape.

Each of the 11 modules is aligned, so everything fits like a glove and is adjust-free. To make things even more on target, our new circuitry

has exacting tolerances. There is no need to re-adjust or realign the remaining circuits if one AccuCircuit is replaced.

Our plug-in modules have replaced a majority of the parts. And since some modules are interchangeable, you don't have to stock a large inventory. Now that's easy servicing.

Let's face it. When it comes to a television chassis, it's the CTC49. Undoubtedly the second and most interesting chassis in the world.

Call your distributor to find out when you can visit our RCA Technical Manual Training Distributor Workshop and get a CTC49 Technical Manual free.



RCA



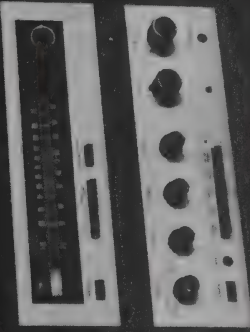
Circle 16 on literature card

March, 1971/ELECTRONIC SERVICING 31

Fig. 19a: RCA's "What a Chassis" ad (*Electronic Servicing*, Mar. 1971, p. 31)

paired for top performance

For the audiophile who prefers to choose separate stereo components, KENWOOD creates the finest amplifiers and tuners for maximum quality and dependability.



KT-2001...FET IC Stereo Tuner, \$89.95
KA-4002...85-Watt Stereo Amplifier, \$199.45
(also available: KA-2002...50-Watt Stereo Amplifier, \$189.95)

For complete information write:

KENWOOD

13714 South Broadway, Gardena, California 90247

Fig. 19b: Kenwood's stereo is "paired for top performance" (*Playboy*, November 1970, p. 83)



Fig. 20b: Altec-Lansing's risqué ad for speakers (*Stereo Review*, February 1977, p. 43)



Fig. 20a: One of Utah Radio Products risqué ads (*Radio Retailing*, January 1929, p. 3)

The Sound Machine

It's an fm/am radio
It's a cassette player
It's a boombox
It's a hi-fi to go
It's a blast.
It's Bell & Howell

BELL & HOWELL

21

Fig. 20c: Bell & Howell's ad for "the sound machine" (*Playboy*, November 1971, p. 31)

For all the specifications, write for our free literature. Send for our new catalog, c/o Virginia Lamm, Dept. SE-4.

But hearing is believing. You can hear Koss Stereophones at your favorite Stereo Dealer or Department Store. At a unbelievable price from \$19.95 to \$150. Small price... to live and let live.

Or try the Koss PRO-AAA Professional Dynamic Stereo Headphones for exacting professional use. And for the discerning music enthusiast as well. Featuring a response two full octaves beyond the range of ordinary dynamics. It's just the orchestra and you... in 100% Row Center.

KOSS STEREOPHONES

Koss Corporation, 4139 N. First Wisconsin Ave., Milwaukee, Wis. 53212
Koss International Ltd., Via Vittorino, 21 20137, Milan, Italy
CIRCLE 80 ON READER SERVICE CARD

Live and let live

10—20,000 Hz
10:30 pm—1:25 am

Fig. 20d: Koss's sexy headphone ad. (*Esquire*, November 1971, p. 201)

CBS Electronic Video Recording (EVR) and the World's First Video Teleplayer

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The first home video player system, known as Electronic Video Recording (EVR), was designed by Dr. Peter Goldmark, president of CBS Laboratories in the early 1960s. The EVR system, which led the industry by ten years, was a playback-only system that could not record television signals in the home. Top management at CBS withheld its release until 1968, fearing it would draw viewers away from their TV network programming. Motorola was contracted to finalize the Electronic Video Record Teleplayer portion of the system and was prepared to produce Teleplayers by mid-year 1970. Internal problems at CBS delayed their ability to produce the supporting program material until late 1971. Awash in losses from the delay and facing many emerging competitive systems entering the dawning market, CBS cancelled the EVR project that December. The technologies in the system were astoundingly simple on the surface, but precisely intricate deep inside, and together the technologies produced high quality video and an interesting story. An account of this story is related here, much of it told in first-person recollections by key Motorola engineers who worked on the design and manufacture of the Teleplayer.

Electronic Video Recording (EVR) was the brainchild of Dr. Peter Goldmark, President of CBS Laboratories in the early 1960s when William S. Paley was Chairman of the Board. A native of Hungary, Dr Goldmark came to the United States in the mid-1930s and found his way into a research position at CBS. By 1950, the research activities had expanded to become CBS Laboratories. Dr. Goldmark was well respected for his contributions to CBS television, military electronic countermeasures during World War II, and the invention of the micro-groove long playing (LP) phonograph record.¹ The future of CBS Laboratories was assured when it became a profit

center for CBS by offering research and development services to other organizations that lacked such facilities. The laboratory developed relationships with the U.S. Government, 3M, Philips and a host of others that gave it the standing of a world-class organization.

With a lifelong interest in television, Goldmark personally focused on its future application in the educational field. The traditional uses of TV in education at the time engendered little enthusiasm from administrators, instructors, and students. Goldmark identified the need for an easily scheduled, unobtrusive, quietly operating, television-oriented playback system that could be

used in a fully lighted classroom or other education venue. It could be interruptible for an instructor's remarks or for close examination of a selected scene, and it could be stopped, reversed, and repeated to clarify a point—and then resume—thereby emphasizing rather than downplaying the importance of the instructor. He anticipated acceptance of the new system based on students' enthusiasm for video, learned at home via TV and already well accepted. Furthermore, it could be integrated into the teacher's lesson plans. By late 1959, he envisioned such a concept using leading-edge technologies of the time.

During the annual CBS budget meeting in the fall of 1960, Dr. Goldmark, with great confidence, proposed \$75,000 funding for ongoing development of his concept. Board chairman Paley showed attentive interest as the educational product was described—until Dr. Goldmark mentioned the potential for success in home entertainment by referencing Columbia Records as an example. In milliseconds came the word “NO!” in a sufficiently cold tone that it caused total silence in the room. Goldmark would later write, “But in my enthusiasm for EVR I had marched into forbidden ground, the home. Paley would not allow any of us to produce a device that posed a potential threat to broadcasting.”²

Dr. Goldmark would have to look elsewhere for funding for his video recording scheme. He turned to John Maniello, the lab's VP for marketing and a former Air Force officer, and asked him to contact the Air Force to gauge

their interest in the concept for the U.S. Air Force Institute of Technology (AFIT), which ran one of the world's largest correspondence schools. The Air Force was interested, and they provided \$37,000 (half the investment requested by Goldmark) in 1961 to develop a working model.

Air Force interest in the EVR project waned, and Goldmark would have to struggle for several years between 1961 and 1967 to secure sufficient funding to translate the working model into a commercial product and bring it to market. The scope of Goldmark's struggle for funding is related in a later section, but first, the EVR technology is described. Peter Goldmark wrote an excellent summary of the EVR technology, which he described in detail for the first time in the September 1970 issue of *IEEE Spectrum*.³

EVR Technology

The CBS version of electronic video recording consisted of a cartridge containing prerecorded video programs (including audio), and an EVR player that reproduced the program on the cartridge through a standard TV set. The version of the prerecorded cartridge and the player ultimately manufactured by Motorola are shown together in Fig. 1. With a hole in the center, the thin EVR cartridge had the appearance of a record, and indeed it was also referred to as a record or a disc. In a very real sense, the EVR player was a video counterpart of a record player because it was a playback-only system that was not able to record video from the television. The third



Fig. 1. The EVR Teleplayer illustration from Motorola. (Motorola User's Manual, front cover)

component of the EVR system was the electron beam recording equipment that made the master for the photographic film used in the cartridges.

The EVR Film

Inexpensive black & white film was chosen as the high-resolution storage medium used in the playback cassettes,

CBS Electronic Video Recording (EVR)

which looked like a record (see Fig. 2). An electronic version of a flying-spot scanner using a cathode ray tube (CRT) was developed by the CBS Laboratories as the light source for scanning the video images recorded on the film. The CRT scans the film image by having its flying spot projected through the film by suitable optics such that the light is modulated by the film and converted by photomultiplier tubes into luminance and color signals. The CRT is 3 inches in diameter and 7.8 inches long.⁴

Solid-state circuitry provided film speed control and generated the blanking and sync pulses, which were combined

with video and sound to produce the signal sent to a TV set. Here was the ultimate teaching tool, equivalent to a personal TV station in the classroom, all controlled by the instructor.

The video record information was stored on 750 feet of specially produced black & white EVR photographic film 0.344 inches (8.75 mm) wide and 0.0032 inches thick, which was stored in a spill-proof, self-threading 7-inch diameter cassette. As indicated in Fig. 2, each film image measured 0.083 inches high and 0.110 inches wide, with an almost grainless emulsion.⁵ The film had two sets of images for programs A and B, which

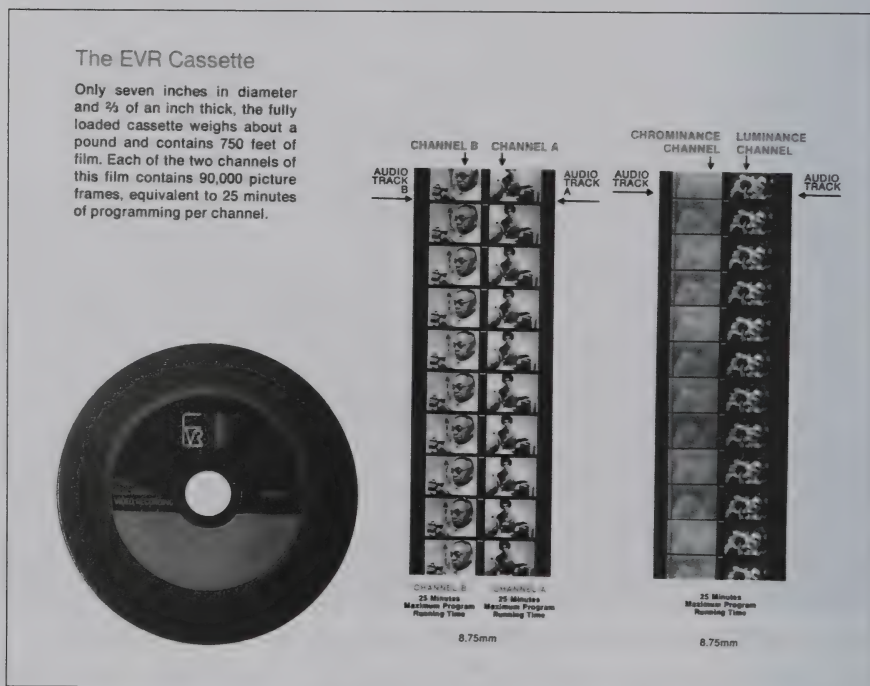


Fig. 2. A self-threading film cassette (left) is placed on the spindle and played after the door is closed. Examples of monochrome and color film (right) each have a width of 8.75 mm (0.344 inches). Note the vertical sync windows are in the center of film. (CBS Electronic Video Recording sales brochure)

were set side-by-side across the width of the film. The film moved in a constant non-stop motion, and was scanned as it passed through the film gate at 5 inches per second.

The block diagram for the black & white version of the video player is shown in Fig. 3. Program A, shown to the left of the diagram, was played first, and was automatically stopped just before the end (usually at 25 minutes) for rewinding. Then program B on the other edge of the film was accessed and similarly played, giving a total of 50 minutes playing time.

The block diagram for the color video player is shown in Fig. 4. The black & white (luminance) portion of the image was recorded on program A. The chroma (color hue and intensity) information was recorded directly alongside (expressed in black & white) on program B.⁶ For color

operation, the player viewed both images at the same instant in order to reproduce the color television signal. Since color used both programs on the film simultaneously, the playing time for color was limited to 25 minutes. Two magnetic tape audio tracks were also provided, and stereo sound was available in the color mode. In still-motion mode, the player scanned a single set of stationary images.

The EVR had a surprising data storage capacity. Containing the equivalent of 180,000 pages readable one page at a time, a single black and white cassette could hold several 26-volume sets of encyclopedias. For comparison, during the early 1960s the data density of an EVR cassette exceeded that of many computers of the day—and at a small fraction of the cost. Film was a viable economic choice.

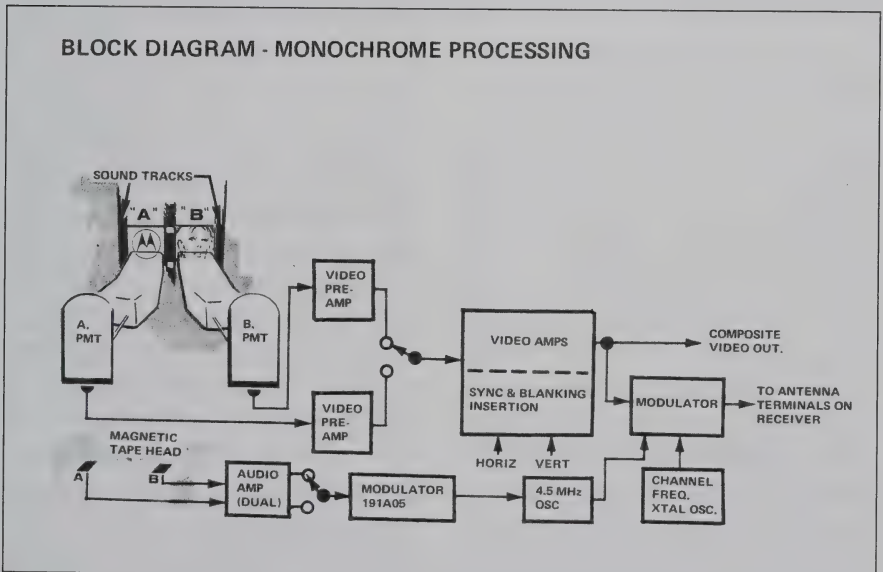


Fig. 3. A block diagram showing the monochrome video signal processing path from film to the antenna terminals of the TV set. (Motorola Service Information)

BLOCK DIAGRAM - COLOR PROCESSING

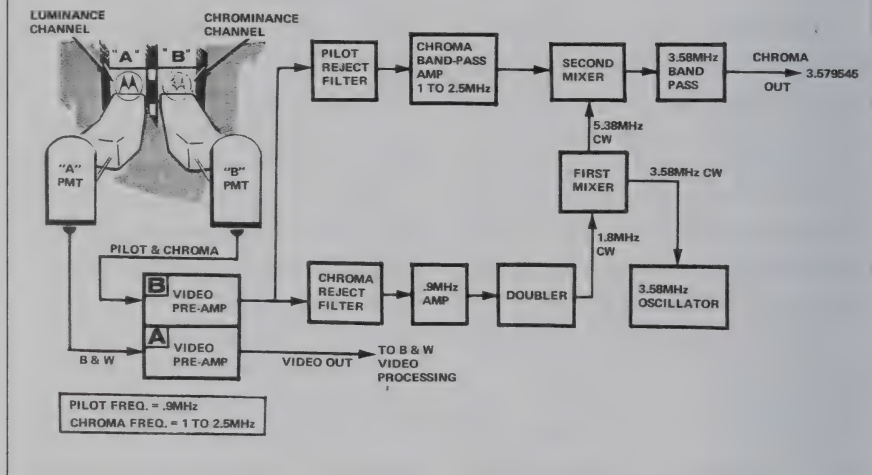


Fig. 4. A block diagram showing the chroma (color intensity) signal processing path from film to TV set. Note heterodyned frequency conversions. (Motorola Service Information)

EVR Film Masters

The video program content for master films from which commercial copies were made originated from black & white or color videotape, or from 35 mm film that was converted to the EVR signal format. Film masters were recorded on film stock several millimeters wider than the film used for finished product, preventing accidental misuse and resultant damage to a master.

The EVR master film emulsion was exposed using an intense electron beam with a diameter measured in micro-inches, and it was scanned in a vacuum chamber at 15 times its playback speed. The film emulsion was not sensitive to ordinary room lighting and could be processed without a darkroom. This new

method, then recently developed by Eastman Kodak Company, was known as the Electron Beam Recorder (EBR). The control room for the EBR is shown in Fig. 5. As the project developed, two of Europe's largest chemical companies, Ciba and Imperial Chemical Industries, Ltd. (ICI), together with the long-established British photographic company Ilford Ltd., were selected to adapt and apply the EBR technology to produce EVR film. CBS would later join them in preparing to record and duplicate EVR film.

EVR Film Duplication—Contact printing

Contact printing is an age-old reliable method for transferring high-resolution images from one source to another, pioneered by the motion picture industry.

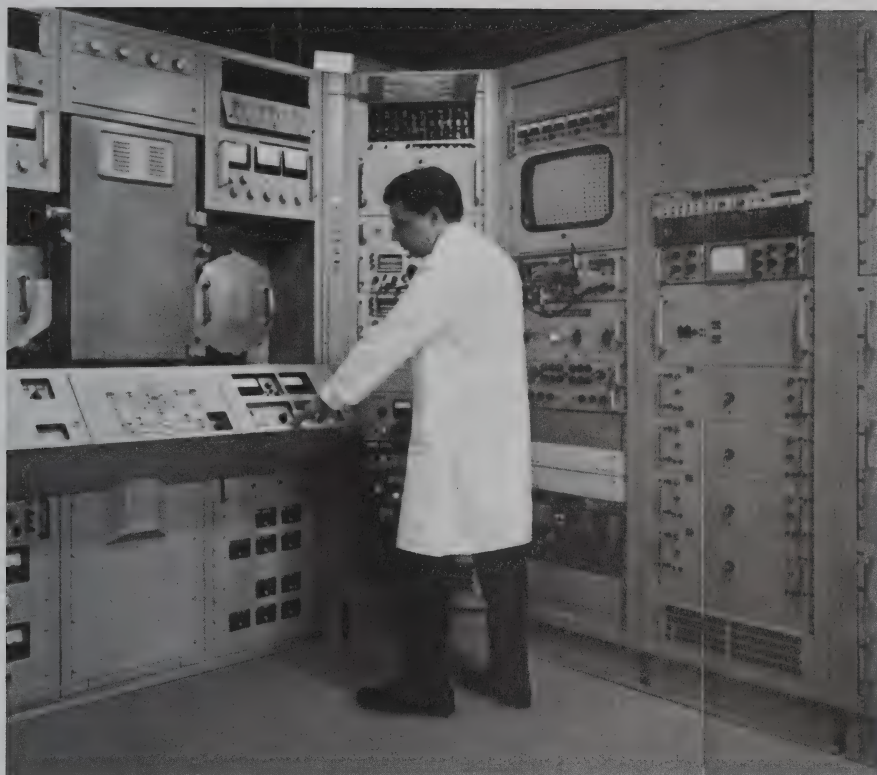


Fig. 5. CBS Electron Beam Recorder (EBR) processing facility with high strength doors visible on vacuum chambers. (<http://www.bretl.com/documents/EVRCassetteProcessingFacility.pdf>)

The fine-grain image emulsion was rated at a resolution of 400 lines per millimeter, and was theoretically capable of an 800-line raster on each image. Thirty-five millimeter film stock was used, producing four EVR films at a time after slitting. It was planned to operate the printer at 40 times the playing speed, 200 inches per second, additionally compatible with recording the magnetic sound track. In a process known as “wet-gate contact printing,” the master film was lightly coated, or “wetted” with an inert chemical having the same refractive index as the film base, thereby hiding scratches

and minor imperfections in the master film during contact printing. Following exposure, the film entered the chemical development baths, followed by cleaning, drying, surface lubrication, and slitting. The precision and speed of the production equipment was balanced to equate with the huge plant investment.

EVR “TelePlayer” Flying Spot Scanner

The “flying” (scanning) spot of light used to view the film originated on the face of a 3-inch cathode ray tube with a very short persistence screen, which is shown in Fig. 6. It was focused via lenses and

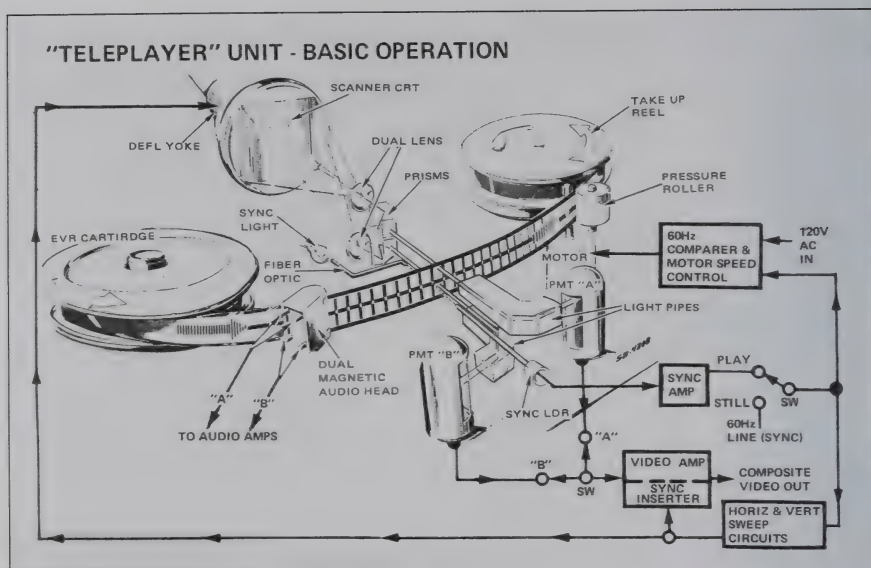


Fig. 6. Exploded pictorial view showing the path from flying spot scanner to composite video output. (Motorola Service Information)

prisms through the film to be directed by optical grade "light pipes" to a pair of photo-multiplier vacuum tubes. The signal then passed through solid-state circuitry to produce color television signals meeting the standards of the National Television Standards Committee (NTSC). The flying spot intensity was monitored by a light-dependent control circuit to maintain constant brightness throughout the life of the player.

The film had an opaque center track placed between the side-by-side images. This track contained small "sync windows" that were clear spots 0.006 inches tall located at the top of each film image. These spots were illuminated by a fiber optic light source in the film gate to sense film speed and vertical sync. Each photographic image on the film when scanned on playback yielded one NTSC field:

262.5 odd-numbered lines. The next field appeared 1/60 of a second later with 262.5 even-numbered scan lines. When viewed simultaneously by the eye, the two overlaid images integrated into one image of 525 lines, repeating every 1/30 of a second. All film images contained a full 525-line raster to avoid interlacing issues, which are discussed in the next section.

Referring to Fig. 7, in order to scan the film while in continuous motion, the scanning aperture in the film gate was two times the height of the image being scanned. When triggered at the sync window (not shown), scanning began as the top edge of the film image was at the top edge of the scanning aperture. The scanning beam moved twice as fast as the film and arrived at the bottom of the image just as it reached the bottom

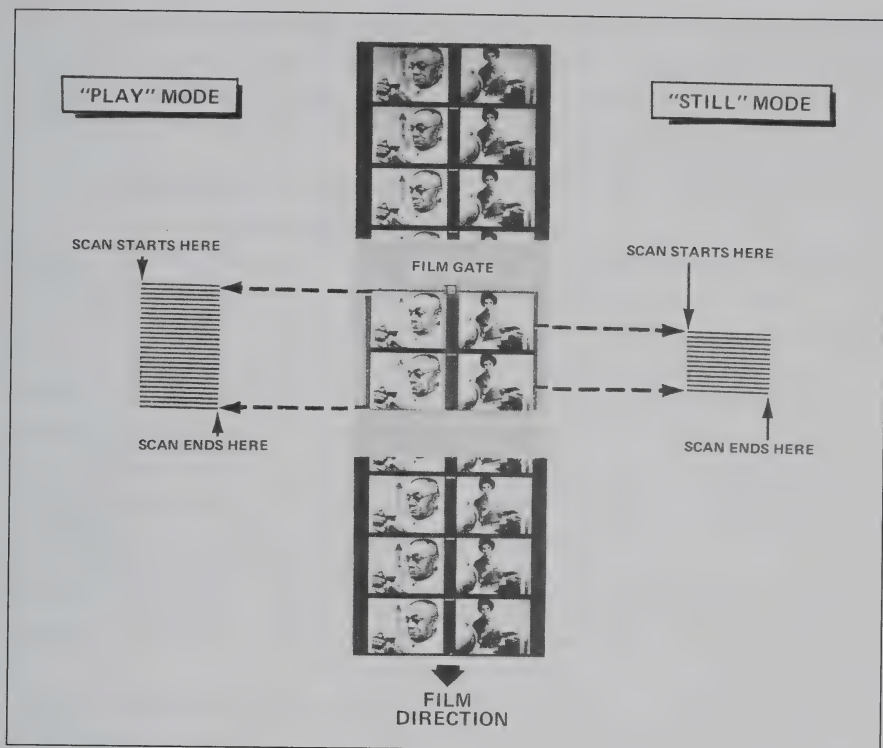


Fig. 7. Vertical scanning in "Play" mode while film is in motion (l) and in "Still" mode when stopped for single frame viewing (r). (Motorola Service Information)

of the film aperture opening. Within microseconds, the next sync window on the film arrived to trigger a retrace to the top, and the process repeated itself.

An electronic phase locked loop (PLL) system ensured that the film drive motor torque was sufficient for the scanning to remain exactly in phase with the power line frequency of 60 Hz (1/60 of a second). This was important to assure stability of the TV sync pulse system in the presence of line voltage variations or varying motor torque demands as reel diameters changed during operation.

When operated in the still-frame mode, the sync generator provided a

vertical deflection timing pulse for the flying-spot scanner to provide a full still-frame image, and the vertical sweep adjusted the height to scan the stationary film frame. Continued use of a still-frame in the same position might result in a "burn-in" rectangle centered vertically on the face of the CRT, and this was avoided by automatic periodic randomizing of the still-scan vertical position.

Interlacing Issues are Avoided

Interlacing refers to the process whereby first the odd lines on a TV screen are scanned and then the even lines, all because the technology could not quite

scan all five hundred lines in the time required for each image before the phosphor began to fade noticeably. Although each image on the film was scanned by 262.5 lines during playback, a full 525 lines were present in each recorded image, which avoided interlace control issues. In the EBR film mastering process, an entire field of 262.5 odd-numbered lines was delayed and held until the next field containing the even-numbered lines began to arrive. Then both were simultaneously scanned. During each horizontal scan line period (62.5 μ sec) the EBR beam was shifted upward and downward one line position. It alternately selected and placed even and odd numbered line positions every 70 nanoseconds (14 MHz rate) effectively delivering two parallel lines at the same time. This process was repeated to deliver all of the even and odd numbered line pairs in the image.

EVR's Unique Color System

The NTSC luminance signal (the black & white portion) was pre-emphasized before recording to match the band-pass characteristics of the system, then routed to the EBR for recording on film program A. The color video information expressed as grey scale lines was similarly pre-emphasized and routed to the EBR on Program B. Inherent limitations in the film recording and playback system necessitated recording the chroma lines at a lower frequency—one half of the NTSC 3.58 MHz subcarrier frequency, or 1.79 MHz. A “pilot signal” at one half of 1.79 MHz, or 0.9 MHz, was included to provide color phase reference at playback. The conversion was achieved

through heterodyning, mixing, and filtering. Circuitry inside the EVR player then reversed the process and delivered an NTSC color signal for TV viewing.

Bringing the EVR Concept to Market—EVR Suitors

The Air Force had provided enough funding to develop a working model for demonstration purposes.⁷ It was now time to find outside funding to turn the working model into a production unit and bring it to the market. Goldmark struggled to find another company or sponsoring consortium to provide the funding that CBS management refused to provide. The serious marketing activities that took place (or did not take place) between 1962 and 1965 are summarized in Table. 1.

The program was dormant in 1966, except for a visit from a representative of the Carnegie Commission on Education that led to a confidential EVR demonstration, resulting in promised favorable words in their impending report. This would turn out to be the break that Goldmark needed, although it did not appear that way at first. CBS top management was shocked when a front-page newspaper article in the *New York Times* appeared in March 1966 describing the CBS EVR system.⁸ As a result, a flurry of trading led to the halting of CBS stock transactions on the New York Stock Exchange. Concerned about potential problems with the Securities and Exchange Commission (SEC), as well as with CBS directors and stockholders, a believable denial story was invented, much to the dismay of the *New*

Table 1. Companies expressing some level of interest in partnering with CBS in EVR.

Year	Potential Partners	Activity
1962	3M Corp.	A working model was demonstrated to 3M. Interest was expressed, but no commitment was made.
1963	Food Machinery & Chemical Co.	FMC expressed interest, but the project was vetoed by FMC president.
1963 (late)	Monsanto Co.	Monsanto provided funds to develop a working model and marketing plans for noncompetitive entertainment films to generate early-market cash flow and royalty fees for CBS.
1964 (spring)	Monsanto Co.	CBS planned to make an offer to Monsanto; Paley vetoed the offer, believing it would detract from CBS TV viewership.
1964–5	No suitors	Without funding, the program lay dormant with minimal sequestered CBS Laboratory activity.
1965	IBM Corp.	Goldmark presented marketing plan with EVR as a purely educational entity. A joint venture with IBM emerged wherein CBS would manufacture film cassettes, and IBM would manufacture the players. CBS's inability to launch EVR in color caused Paley to cancel the proposed deal.

York Times and its business reporter Jack Gould. Later, it was learned that while riding on a train during a trip to Italy, Gould struck up a conversation with one of the Carnegie Commission members who had witnessed Goldmark's demonstration, and he provided an accurate description of the CBS system to Gould.

CBS executives now realized that educators in Europe had enthusiastically responded to EVR as a result of the Carnegie Commission Report. Interest at CBS was further piqued when a British consultant to Borg Warner Corporation showed interest, along with

Doubleday Publishing Company and other influential contacts across Europe. By mid-year 1967, a viable consortium was forming to cover development costs without further financial outlay from CBS. In return, CBS would hold U.S. rights at no cost, and would receive 20% of worldwide profits. Philips Corporation was to manufacture and market players. Also included were Doubleday Publishing and two chemical companies, Ciba Pharmaceuticals in Switzerland and International Chemical Industries in Great Britain.⁹ ICI at that time also had a majority interest in Ilford Limited, a

CBS Electronic Video Recording (EVR)

long-established British company with a large inventory of silver-halide film stock.

CBS prepared a proposal for a partnership with these companies, but once again Chairman William Paley balked. This time he said, "EVR must be good. Why should we be just a minority partner with only 20 percent?"¹⁰ He demanded 50% ownership. Dr. Goldmark and President Frank Stanton justified the original proposition by pointing out that a 50% ownership would require substantial long-term support and funding from CBS. But Paley insisted that CBS must have 50% of the partnership.

On August 27, 1967, CBS announced Electronic Video Recording, or EVR. The *New York Times* enthusiastically called it a revolutionary electronic device that allowed playback of motion pictures or video material through a conventional television receiver. Felix Kalinski, vice president of planning, was placed in charge of working out the legal details, but his path was not a smooth one. In the end, Philips and Doubleday withdrew. The final consortium partnership with the name "Comtec," included CBS with a 50% share also identified as the CBS Electronic Video Recording Division, and ICI plus Ciba Pharmaceuticals with the other 50% share, but no hardware manufacturer was identified. Robert Brockway was assigned the task of marketing and managing the film processing plants. The premier task of the new group was to select a manufacturer for the player.

Aware that film cassette sales were vital to start-up cash flow, Goldmark, Kalinski and Brockway raised the issue

of program material for the EVR films with William Paley a number of times. But he firmly refused to allow use of CBS programming content for the EVR by declaring, "Let everyone who wants to produce a program bring his goods to our processing plant and we'll make money on them."¹¹

Location and operation of the film processing plant was a CBS responsibility. A 104,000 square foot facility in Rockleigh, New Jersey, was selected and leased by May 19, 1969, to house the new Electron Beam Recorder and related activities. Staffing, equipment selection and installation were under way. Paley and his board felt that the newly selected Comtec executives could guide the organization through a successful product launch. Dr. Goldmark was nearing the mandatory retirement age at CBS, and other demanding corporate responsibilities and retirement considerations directed his attention away from the project and the construction of the new film plant in New Jersey. The future would reveal some bad judgment calls.

EVR made its formal debut at the Hilton Hotel in New York City December 10, 1968 using players from the CBS Research Laboratory. The player's target price was \$495 with cassettes priced between \$10 and \$15 each. EVR existed in black and white form only. Color development began in earnest with planned availability by July 1971.

At the same time, color EVR was seen to have potential as an inexpensive, profitable, color television programming source for smaller market black & white TV broadcasters. Work

began on development of an industrial color version known as the "Broadcast EVR," or BEVR. It could be marketed to broadcasters at a small fraction of the 1968 cost of a color camera or videotape machine. At that time the cost of a blank videotape was \$225 for one hour, versus \$30 for EVR film. Considerable corporate urgency was focused on this project, although the urgency conflicted with color development progress for the basic version.

Motorola is Selected as the Player Manufacturer

On December 12, 1968, CBS selected Motorola, Inc. located in Chicago, Illinois, as the manufacturer of the Teleplayer, and the agreement was memorialized by

the signing ceremony appearing in Fig. 8. The project anticipated substantial design modifications to reduce costs and optimize performance within the bounds of the original concepts. Motorola was granted exclusive U.S. manufacturing rights through December 1971. Motorola president Elmer Wavering maintained an ongoing personal interest throughout the program. Working with the CBS team, an 84-week development program evolved wherein CBS would share basic conceptual designs and patents necessary for the project, including development of the color circuitry. In the transitional stages Motorola would optimize the black & white portion of the player, then implement the CBS-developed color design when it was completed.



Fig. 8. CBS and Motorola executives announce the agreement whereby Motorola became the manufacturer of the Teleplayer (l to r): Felix Kalinski, President of Comtec; Elmer Wavering, President of Motorola; Frank Stanton, President of CBS; Peter Goldmark, President of CBS Laboratories; Arthur Ochs Sulzberger, President of the New York Times; Robert E. Brockway, President of the CBS EVR Division. (*Voice of Motorola*, Employee Newspaper, Jan. 1969)

Finalizing the Design

The Motorola design team consisted of a Senior Director of EVR Engineering (Albert 'Bud' Massman), three electrical designers (Wayne Bretl, Rolf Spies, and Emil Bessier), and a mechanical designer (Ted Monaco). The design team operated from Motorola's Franklin Park headquarters near O'Hare Airport through 1968 and well into 1969, in liaison with CBS engineers. Milestones included electrical and mechanical design, cost reductions and improvements, model shop and outsourced fabrication of prototype parts, supplier sourcing, production tooling, and first-piece approval. The major design issues that were addressed are listed in Table 2.

Design engineer Wayne Bretl remembers:

"The only existing CBS players at this time were the engineering models that CBS had designed. The first EVR films and players were black and white. Electrical redesign was in two main areas: video and color (myself) and CRT sweeps and power supplies for the photomultipliers (Emile Bessier). The latter included a photocell feedback for CRT brightness. The CBS player had a vertical position randomizer to prevent burning a sharp-edged dark area into the CRT phosphor. This would occasionally fail and kill the vertical sweep in the still mode, burning a permanent black line across the image. Motorola worked with a CRT supplier expert developing a phosphor that both had finer grain (to reduce stationary picture noise) and was less susceptible to noise.

The stationary noise was eventually reduced by a factor of three or more. At the same time, the burn was minimized to an acceptable level."

Wayne Bretl summarized some of the motor and control issues: "The control circuit presented a problem when the asymmetrical voltage applied to the motor caused a direct current component that produced eddy current drag and dissipated heat into the motor. Early prototype players had a short motor life due to heating, when the bearing oil was cooked into varnish. Looking for a simple solution, I discovered that we could get a capacitor-run motor that would fit. When it worked, the new motor was included in the design."

By early 1970, an intermittent mechanical problem persisted. Wayne Bretl continues:

"Occasionally the film leader would trip the mechanism from threading mode to play mode without being captured on the internal take-up reel by the first leader notch. There would be no indication this happened until you finished the film and tried to rewind the jumble of film in the take-up well. I realized that if the trip location was moved half way around the reel, the leader might still not be caught properly, but it also would not trip into play mode. Then, when the take-up reel rotated another half turn, it would definitely engage the second notch in the leader. I took this idea meekly to Bud Massman (after all, I was not the mechanical

Table 2. Design activities addressed during 1969 and 1970.

Optimize mechanical functions, control button mechanisms, and locations for smooth and reliable operation.
Design plug-in circuit board panels ("Motorola works-in-a-drawer") for ease of servicing.
Optimize drive motor phase-locked loop (PLL) to reduce heating.
Reduce cost of cathode ray tube, improve brightness and reduce spot size.
Optimize film gate assembly, find a suitable source, reduce cost, perfect the finish in the film contact area.
Optimize film gate light pipe end finish and the installation process.
Locate up-to-date semiconductor sources, control costs, and optimize circuitry for devices.
Minimize CRT image burn.
Design video delay line for Motorola manufacture.
Design CRT brightness control sensor to assure long-term uniformity.
Achieve reliable automatic film threading.
Eliminate vertical jitter.

engineer), who then had me present it to Ted Monaco, the chief mechanical engineer. This proved to be the fix."

Wayne Bretl described the first encounter with CBS EVR color:

"CBS had been supplying test cartridges of ten minutes of updated monochrome as they made improvements. The improved material was located at the start of the reel with sufficient filler film added to enable automatic threading. One of the cartridges they sent had filler containing experimental color material. There were color stills from a Chevy

commercial and two pictures of the Skipper and Gilligan from *Gilligan's Island*. After several filter adjustments, we had a nice blue Chevy and a picture of the two actors in their bright red and blue shirts. Then someone in the lab who actually watched *Gilligan's Island* pointed out that the red shirt should be blue and vice versa! Consulting the CBS documents, we discovered that the color phase sequence was reversed on the film (it was supposed to be because of the heterodyne process they used to trans-code the color). Some circuit modifications were made, and the shirts were corrected. The Chevy changed color too. Later, when CBS

gave us official color material, we surprised them with our quick response.”

Factory Preparations in Late 1969

Since the EVR player included a number of new technologies, it was vital to have an experienced technical staff in both the factory and design engineering groups. Therefore, an EVR technical group at the Motorola assembly plant at Quincy, Illinois, was organized within its New Products Department. It already contained engineers seasoned in mechanical assemblies and television production, among them, Jim Sibbing, Don Rust, and Olin Shuler. There was ample workspace and a competent team of skilled manufacturing personnel available for recruitment into the EVR project. Locating the activity to the factory provided the on-site training opportunities to develop the necessary expertise for a successful production launch.

In the final months of 1969, the first official working models arrived at Quincy from design engineering, along with full sets of documentation and a nearly constant presence of design engineers from Franklin Park. The player units already contained CBS color circuitry; however, the circuitry was still under development and subject to design changes. Preparations went forward with the available information. The plant's early exposure to EVR involved primarily the performance of black & white version of the player.

Jim Sibbing picks up the story at this point:

“Early on, the major problem was that both the player and film processes were

being developed simultaneously, and many problems were not easily distinguishable as film faults or player-related. During this period, film was in very short supply. It seemed as if every time we received a few samples, new or different problems would emerge in the player.

“A thin film base (0.0032 inches) was required to achieve 25-minute running time. Some early problems related to the use of acetate-based film, and its tendency to stretch during printing, running or rewinding, resulting in vertical sync instability. Film stretching caused the sync pulse window on the film to arrive late, causing jitter. A change in film base material solved the problem.”

Jim Sibbing and Wayne Bretl recall some of the early film lubrication difficulties:

“Since the emulsion side of the film was in sliding contact with the film gate, lubrication was essential to protect the emulsion from wear and prevent clogging and obscuring the tiny fiber optic orifice that read the sync window. Many types of silicone and other lubricants were tested; coating thicknesses were varied until the optimum lubricant was found.”

As the newly tooled unique EVR parts arrived and were inspected, their related problems were addressed and corrected as they occurred—not a small task in itself. Critical assembly steps were identified and special positioning fixtures

or measuring tools were provided and integrated into the appropriate workstations. Motorola President Elmer Wavering began a series of monthly visits to the Quincy plant accompanied by Director of EVR Design Engineering “Bud” Massman. The adherence to the 84-week timeline was examined along with frank discussions about the challenges and their solutions. Elmer referred to tough problems as items for “pillow-talk” with Bud.

Meanwhile, industrial engineering and time study engineers identified each labor motion required for assembly and allocated predetermined standard times for each operation. From this information came an accurate calculation of labor content and cost. Expressed in hours per 100 sets, the number of workers for given daily output was calculated. The labor steps in sequence were equally divided, balanced between each workstation in a document known as a “line balance.”

The new products team assisted by the Test Equipment Department provided needed support. The EVR used 12 plug-in panels that required pretesting before they were loaded into the player chassis (see Fig. 9). The unit’s photomultiplier tubes were sensitive to daylight, so a special dark room was required for CRT assembly setup and related circuit board adjustments. Since the tubes were not sensitive to the yellow light from commonly available outdoor incandescent bulbs designed to avoid attracting

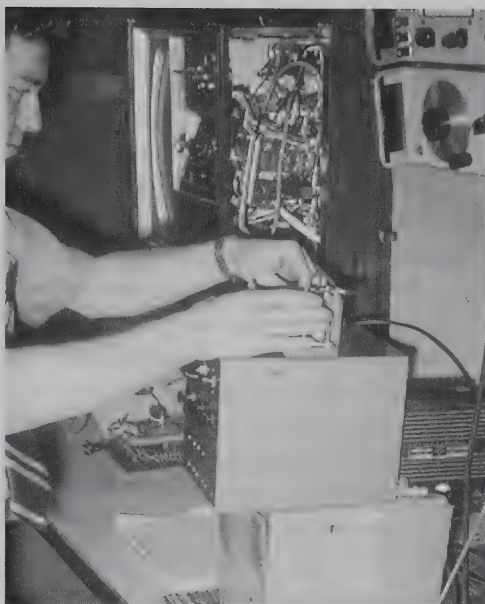


Fig. 9. Article contributor Don Rust readies a PC panel test fixture in the spring of 1970. (Author’s collection)

nighttime bugs and flying insects, they were used to light the dark room.

Wayne Bretl continues:

“I designed a signal simulator that could be used to align the player color circuits without the flying spot tube, film, and optics being connected. Quincy built several copies for use on the production line. The signal represented several horizontal bars of magenta color (five, if I recall), each with a different coded frequency to simulate scan nonlinearity. The output was viewed on a color monitor and the outer bars (towards the top and bottom of the screen) were made to match the hue of the center bar by tuning the coils in the color section, one for each bar.”

Pre-production Pilot Run Assembly and Problem Solving (February 1970)

One hundred units were fabricated during a trial production run in the New Products Department at Quincy (see Figs. 10 and 11). Sufficient color information and film became available, and test adjustments and measurements were logged. Then came the time for hands-on experience (see Figs. 12 and 13). In mid-March 1970, week 65 of the 84 week schedule, the optimized changes in the chroma circuit board arrived as redesigned by Motorola's Franklin Park team. Wayne Bretl recalls:

“The Motorola color circuits design, however, was very different from the CBS design. And of course, Quincy had built a run of CBS prototypes for



Fig. 10. Convenient multi-position holding fixtures in use at the pre-production assembly at the Motorola plant in Quincy, Illinois. (Author's collection)



Fig. 11. Assembly instruction documents were used during the pre-production assembly line in the plant at Quincy, Illinois. (Author's collection)



Fig. 12. The production engineer, assembly foreman, and QA supervisor examine the player during a trial production run in the New Products Department at Quincy. (Author's collection)

the big press announcement and for optimizing the design. The major difference I recall there was in the color decoder. CBS had used band stop filters to separate the chroma signal and pilot signal on the film. This caused a phase (hue) shift with horizontal scanning rate, due to the resulting changes in the chroma and pilot frequencies. I came across a lattice band-pass filter design published by R. M. Lerner

in the May, 1964 *Proceedings of the IEEE* that allowed the phase shift versus frequency to be adjusted to be almost perfectly linear. Also, CBS used heterodyne techniques to convert the film signal to either NTSC or PAL. This could have problems if the mixers were not precisely linear, producing a vertical bar pattern. I redesigned the circuits to demodulate the film signal to baseband R-Y and B-Y, and then remodulate to either NTSC or PAL."

Jim Sibbing recalls:

"Easter weekend of 1970 saw an all out effort at the Quincy plant to prepare updated players for an upcoming major showing. A few days later, Olin Shuler and I recall taking cartons of EVR players to Quincy Airport (UIN), loading them aboard a waiting CBS Gulfstream Jet and wondering if this was 'Walter Cronkite's airplane.' Bud Massman was aboard, greeting us en



Fig. 13. Process and quality engineers examine and plan during a trial production run in the New Products Department at Quincy. (Author's collection)

CBS Electronic Video Recording (EVR)

route to the first public showing of color EVR at the Hotel Pierre Grand Ball Room in New York City on March 24." A related press release fact sheet indicated EVR color cassettes would be available by autumn of 1970, a full year ahead of schedule.

Film Gate Issues

The film gate, which was the most expensive component in the player, is shown schematically in Fig. 14, and a photograph of this component appears in Fig. 15. The original CBS prototype gate cost more than ten times the projected retail price of a production player. The final mass-produced film gates cost less than 1% of that amount. The development of the gate shape (curvature) and surface finish was a heroic effort. Ted Monaco, the chief mechanical engineer on the project, and a top supplier, Serv-All Tool and Die Co., won awards for their parts in development of its manufacturing process.

Jim Sibbing and Don Rust played major roles in the film gate project, concentrating on the precision required in assembly. The EVR film gate provided the only guidance positioning of the constantly moving film, and so incredible accuracy and uniformity of film width was required. That problem was solved by improving the slitting technology used by the film processor. A stereo-zoom microscope with a micrometer stage graduated in ten-thousandths of an inch was used to verify proper location of image frames, vertical sync windows, and audio tracks with respect to the guiding edges of the film stock. Film gate assemblies were assembled and pre-tested offline in a nearby clean room. Quantification and control of each variable required time, numerous trial runs, out-of-the-box thinking, and in one case, alternate suppliers.

There were also many tolerance issues. For example, the zinc die-casting of the film gate required dimensional

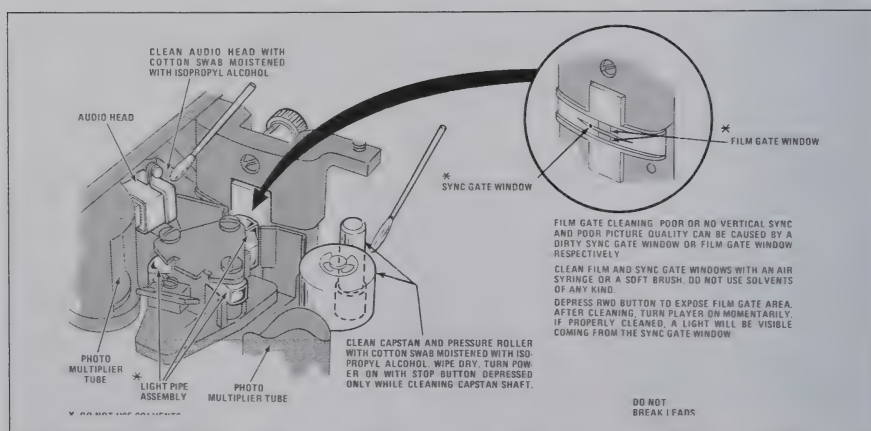


Fig. 14. The high-precision film gate shown schematically in the circled area was the "heart of the unit." (Motorola Service Information)



Fig. 15. A close-up photograph of the film gate shows the film edge guide rails and center rib with the fiber-optic orifice. (Author's collection)

uniformity to a variation of 0.001" between multi-cavity molds for selected dimensions and chrome plating; and polished surfaces required a 10-micron finish. Also, the radius of the guide was critical for alignment with the mechanical reeling mechanism to reduce friction but maintain intimate contact of the film to the gate. The gate guide was designed so the film would ride guided by rails at the edges and one in the center. Another issue was the center rail, which required minimum friction when detecting the vertical sync window on the film to preclude damage to its integrity. A final example was a 0.010" fiber optic cable that needed to sense the vertical sync window on the film. The exposed fiber optic surface had to bear the same radius flush with its surrounding rail, presenting a continuous curved contour for film contact. If it were positioned too high, damaging wear would occur on the film emulsion surface, but if it were placed too low, light input was diminished, and the gap would attract film lubricant residue and dirt that would result in loss of vertical sync. The available amplitude of the vertical sync pulse was increased by a circuit change from sensing by a light dependent resistor to a light dependent transistor.

Gamma Curve Issues

Wayne Bretl explained the issues dealing with gamma, which is the variation of gray scale between white and black:

"There was a variation in exposure of the electron beam during recording of a single program and at times from program to program. It changed the over-all exposure and gamma curve of the prints drastically when not properly compensated. The gamma curve was deliberately added to stretch the highlights in recording. In the player, the highlights were compressed back to normal, so that the flying spot CRT phosphor grain was made less visible. This gamma curve was also applied to chroma/pilot frames. When the recorded expansion did not match the player's compression, it would introduce crosstalk from the chroma into the pilot and distort the hues. Peter Goldmark thought of the ingenious innovation to make the pilot phase the same hue as skin tones. When crosstalk occurred, it did not alter skin hue, but all other hues (greens, magentas, etc.) would move either toward or away from skin tone."

Vertical Jitter Issues

Wayne Bretl describes another issue:

"Vertical jitter had its root cause in the integrity of the sync pulse source. This was solved by triggering the vertical sweep from the optical sync track pulse, which occurred when the frame was properly positioned in the gate. Early monochrome players simply

guided this light into the photomultiplier tube for detection, while later designs used a light dependent resistor and eventually a phototransistor.”

Federal Communications Commission Radiation Compliance Issues

The EVR player was one of the first to require what is now known as FCC Part 15 Radiation Compliance Statement. Wayne Bretl explained:

“Another area where Motorola did pioneering work was on the RF channel 3 modulator for output to television sets. Player RF signal strength and related radiation limits had not been established. We did video noise versus signal level tests, and also interference radiation tests at the open field facility in Schaumburg, Illinois. We had to do the latter in the middle of the night, because there was a Channel 3 television station across Lake Michigan in Kalamazoo that would interfere with our measurements. One night, Kalamazoo came on the air at 3 a.m. for transmitter tests, and I had to find their phone number and ask the engineer if he could shut down until their regular morning schedule. Anyway, all this resulted in establishing the FCC standard RF output level for VCRs, cable set-top boxes, and all the rest.”

Teleplayers for the United Kingdom Using Their PAL Signal Format

The EVR was designed to provide a NTSC signal for use in the United States. The two large European partners in the consortium desired a PAL (Phase

Alternating Line) system version for their use. Franklin Park engineering came through with the design modification. A PAL version pilot run was scheduled and successfully completed. The necessary test equipment was obtained for specifications compliance data. That production run was particularly helpful in confirming the ability to meet PAL specifications along with the robustness of the commonly shared portions of the player. A moderate number of sets were built and shipped to specified destinations for sales promotions in Europe.

EVR Player Approved For Production

At week 84 of the EVR program, Motorola engineering and production management agreed that the product and processes were sufficiently robust to begin production. The finished player minus the covers, at it appeared at this time, is shown in Figs. 16–18. It was learned via the Motorola company president that there was a delay in production startup at the New Jersey film plant. The Quincy plant was ready to activate production lines 60 through 63 for an initial 300 unit per day run with a delayed start date in September 1970. In the meantime, a quantity of players had been tested versus all characteristics in the specifications to establish statistical confidence in their ability to meet requirements. The routine shipping drop tests, vibration tests and life tests were completed.

A number of engineering changes to further optimize performance were tested on the newly established production line that was used as a convenient

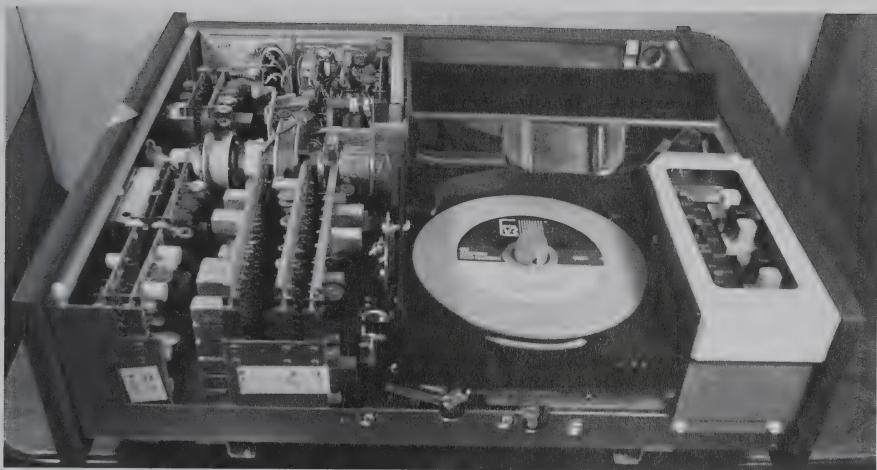


Fig. 16. A finished Teleplayer minus the covers, as it appeared in early 1972. Note the small CRT in the center left. (Author's collection)

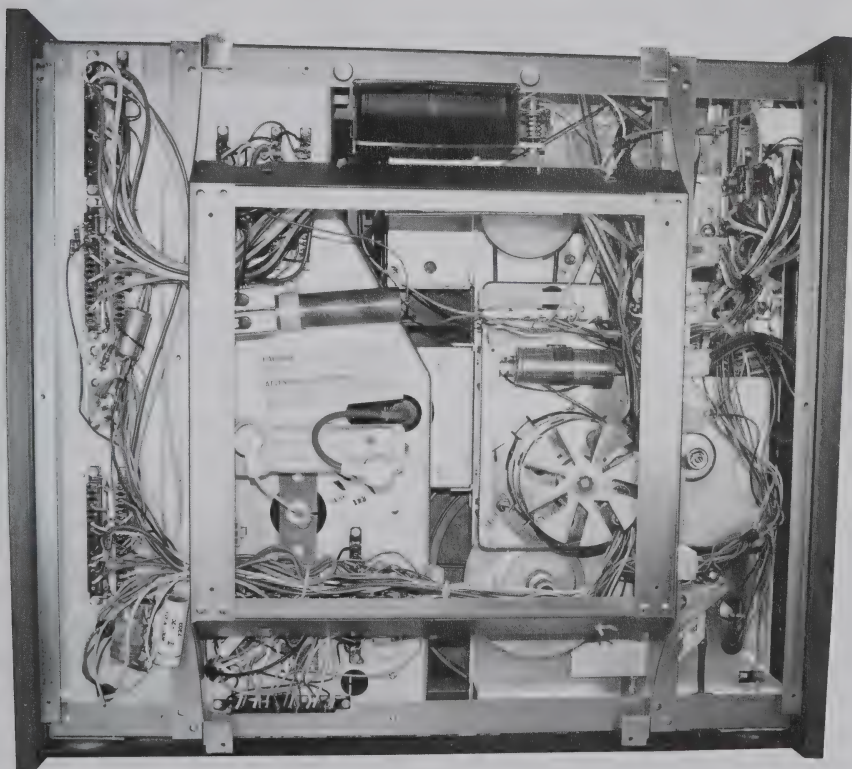


Fig. 17. Bottom view of a Teleplayer showing a larger-than-usual video delay line in the center of the picture that was needed for the chroma signal path. (Author's collection)

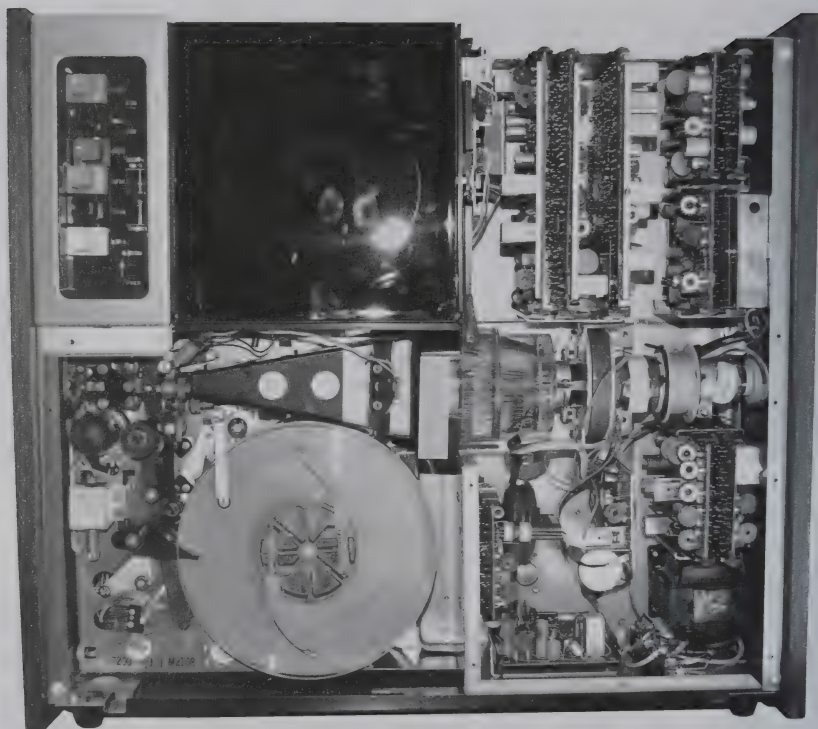


Fig. 18. Top view of the Teleplayer with the opaque cassette door covering the film reel compartment. (Author's collection)

test bed. A series of 400-hour life tests were successfully performed on 30 players to pinpoint trends toward early life failures. The information indicated sufficient reliability to approve the product for production. Product and process improvement activities continued in anticipation.

On September 6, 1970, a tornado struck the plant, tearing a huge gaping hole in the roof above the EVR line just before 4:00 PM. The factory maintenance crew and other able-bodied helpers covered the line with tarpaulins and provided instant cleanup, thereby

avoiding significant damage. As a result, conditions returned to normal within a few days.

After the starting date for production was delayed, it was learned that the program lacked sufficient quantities of film cassettes to support the market. Financial planners had originally established a break-even point of 500,000 cassettes annually. CBS insiders were aware that a series of major mistakes had been made in plant equipment selection, process planning, and staffing that caused cost overruns and schedule delays. In 1970, CBS lost four million dollars (\$26 million

today). Shortcomings in the New Jersey film plant eventually resulted in a full year's delay (into 1971) with attendant financial losses. Player startup and sales introduction were delayed while corrective efforts continued. Dr. Goldmark observed, "CBS made all the mistakes in the book in the course of equipping and running the plant."¹²

As 1970 wore on, critics began to criticize EVR as a "play-only" unit, incapable of recording. Dr. Goldmark countered by envisioning users of 8mm home movie cameras shooting their film as usual, but instead of the popular mail-in processing, exposed film would be developed by an expedited EVR service center, with a cassette promptly returned to the customer, ready for viewing via the teleplayer. However, the marketing team felt this approach would detract from existing sales and marketing plans.

As late as mid-1971, a reliable start-up date could not be established for the EVR player. Production was limited to a few short runs to supply sales demonstration programs and promotions. When continuing product improvements were forthcoming from engineering, the awaiting EVR production line was used for the "unpack – rework/test – repack" operations needed to install the latest changes in the minimal finished goods inventory. Motorola's processes were kept up to date and ready for an immediate start-up. President Elmer Wavering's monthly visits continued, confirming unwavering readiness. By late summer, Motorola logistics and production

scheduling personnel realized that, if given an immediate startup, 20,000 units could be produced before year's end, at the scheduled conclusion of the CBS contract.

Motorola was active in the promotion of its Teleplayer as a teaching tool in the fields of public safety, business, industrial training, and many others, plus entertainment. A typical example of a sales brochure (Fig. 19) consists of a collage of newspaper articles lauding the benefits and superiority of the Electronic Video Recording technology, specifically identifying the Motorola Teleplayer.¹³ The concept of small businesses operating EVR cassette rental stores emerged as a revolutionary idea. Appealing to a broader customer base was obviously required in order to reach the financial break-even point. Belatedly, CBS stepped up marketing development of educational EVR cassettes, without notable results. In Britain an EVR film catalog was released, listing 2000 potential subjects and titles.

Since start-up was imminent, Quincy activity came back to life. Production started in late autumn 1971. It appeared the program was finally on its way. There were no significant start-up interruptions, thanks to the skilled, well-trained people on the production assembly line. The processes were working, and players were being completed, tested, and packed (see Figs. 20 and 21).¹⁴ But it all came to an abrupt halt about three weeks later. And then there was silence, just silence until the news came from CBS top management.

Cartridge of the month surely will be a reality

"Both CBS and Motorola spokesmen have stressed that the initial EVR system is designed for business and industrial use, but acknowledged it is the precursor of a new phase of home

entertainment equipment which ultimately will enable a TV set owner to screen his favorite motion pictures at any time."

Oregon Journal

TV EQUIVALENT OF LP RECORD SHOWN IN EVR DEMO

"It's only a matter of time before you'll be able to see your favorite Walt Disney G-rated movie; or the X-rated *Midnight Cowboy*; or the XXX *I am Curious (Yellow)* in your living room, on your own TV set, any time you please."

Philadelphia Inquirer



Pick TV Programs from album rack

"The dream of picking up a new movie at a supermarket or taking it out on loan from a library no longer seems quite so remote. The EVR system gives the viewer the power of choosing the program he wants to see in the same manner as he can buy a classical or rock music album. He can play the program at any time, and there are no commercials."

Chattanooga Daily Times



Fig. 19. An excerpt from a Motorola EVR folded promotional brochure with a reference on the right to 1970s TV stars being signed by Motorola. (www.bretl.com/documents/MotorolaTeleplayeraccordionfold.pdf)

FILM PRODUCERS TO REAP NEW PROFITS

"Fox's Zanuck hailed EVR as a major development in film presentation. He compared EVR with the advent of sound, color, and Cinemascope, and said that EVR in his judgment, promises to broaden considerably the horizons of film profitability.

He later commented that the strength of EVR lay in the quality of its color reproduction; the modest rental price which will make it available to the mass market; the mechanics which provide a defense against unlawful copying and bootlegging of prints, and all the benefits which will accrue to all segments of the film industry — producer, distributor and exhibitor — through the expansion of the market for feature films."

Variety, New York

EVR Beats Competitive systems

"Zanuck said that he and his technical people have looked at other systems and came to the conclusion that this (EVR) is the best . . . the simplest to control. He also made the distinction that the EVR cartridge market is viewed as separate from the TV syndication market and that 20th would stay in both."

Film & Television Daily

General Music of Atlanta signs with Motorola

" . . . Leonard Elliott, chairman of General Music, said his firm is combining production of EVR cartridge music education courses with marketing of the Teleplayers for use by educational institutions. This agreement makes General Music one of the first combined-distributors to produce educational programming specifically for the EVR format."

Home Furnishings Daily



Motorola inks deal starring Rowan & Martin, Jack Benny George Burns . . . others to follow

"Motorola recently reached agreement with Arm Productions, Los Angeles, for production of three EVR programs, starring Rowan & Martin, Jack Benny and George Burns . . . (ARM president Norman Abbott revealed in a joint announcement with Motorola).

The program is designed, initially, for Motorola's hospital package—for viewing by patients bored with normal broadcasting fare. Other programs could be produced for home screens when system is made available to the private consumer . . . expected sometime in 1972."

Daily Variety, Hollywood



Fig. 20. A completed Motorola Teleplayer unit with the original carton. (Author's collection)



Fig. 21. An employee is packaging finished Teleplayers on Line 63 for shipping from the Quincy, Illinois plant in late 1971. (<http://terramedia.co.uk/media/video/evr2.htm>)

CBS Cancels the Project

As 1972 approached, CBS began examination of 1971 accounting results. As EVR film cassette production ran far short of goals, the costs of continuing were recalculated. The Motorola player retail price was firm at \$795. The CBS projected price of cassettes had been driven up by technical difficulties to an unattractive \$84 each. Several million dollars of additional investment, plus costly lead time, were needed to achieve desired economies of scale. CBS Chairman William S. Paley made the decision, and the announcement of the EVR project cancellation on December 23, 1971 was reported in the *New York Times* the next day.¹⁵ The after-tax cost of the cancellation was reported to be \$10 million. The 10-year lead time that CBS had in the industry in 1962 had evaporated. There would be no profits to split. Motorola's exclusive U.S. manufacturing rights expired as scheduled on December 31, 1971.

In the wake of the news, many committed customers and major prospects pulled away as the EVR interest and enthusiasm collapsed. The possibility of a Motorola marketing venture was envisioned but fell by the wayside within a few months. Motorola Education and Training Products continued to operate from its offices in a former Motorola plant at 4501 West Augusta Boulevard in Chicago. Efforts were made to market EVR players and training cassettes for public safety, educational, and industrial training.¹⁶ Other prospective users included the *New York Times*, Trans World Airlines for aircraft maintenance

training, major insurance companies for sales training, medical school training, the State of Hawaii educational system, and many others.

Motorola production lines were on hold until early 1972 when work-in-process units were completed and packaged. The EVR equipment was removed from the lines. Useable equipment items went to other lines as color television output increased. The plant production engineers, although disappointed that the project they had helped perfect for production had ended, were busy expanding the television production business. Unique EVR test equipment was stored as a hedge against future developments. A year later, in 1973, when the inventory was sold off at surplus prices, your author purchased one. It was used for a number of photos that appear elsewhere in this article.

Epilogue

Another Consortium

In 1972, yet another consortium with original EVR partners Ciba and ICI was formed—this time in Japan.¹⁷ They were joined by Teijin, Hitachi, Mitsubishi, and Mainichi Broadcasting. With the new name, “New International Electronic Video Cassette Company Nippon EVR,” it was likely envisioned as a niche market product in spite of the success of competitive systems. Hitachi produced EVR players in Japan into 1974.

With the CBS film plant in New Jersey closed, the sole source for film mastering through 1973 was in Basildon, Essex, England, half way around the world from Japan. Consortium partner

Teijin opened an EBR film mastering plant in Hiroshima Prefecture, Japan, in August 1973, shortly before the Basildon plant closed. Its targeted output was 20,000 cassettes per month by early 1974, but the world economy was hard hit by the energy crisis of 1975, and industrial growth plummeted.

And Another Consortium

In 1975, an arcade games manufacturer teamed with Mitsubishi in a video game venture based on the EVR technology. Repeated attempts to bring this to market were unsuccessful, and the last traces of commercial use faded from the picture by 1977. Today, the EVR and its player continue as an item of interest and technical curiosity among vintage equipment historians, restorers, and collectors.

Endnotes

1. LP records were induced by Columbia Records in 1948.
2. Peter C. Goldmark, *Maverick Inventor: My Turbulent Years at CBS*, (E. P. Dutton & Co., New York, 1973) p. 172.
3. Peter C. Goldmark, "Color EVR, IEEE Spectrum," Sept. 1970, pp. 22–33.
4. *Ibid.*, p. 29.
5. "EVR CBS Electronic Video Recording," undated brochure, p. 2; <http://www.bretl.com/documents/EVRCBSElectronicVideoRecording4pp.pdf>.
6. Chroma is one of the two components of a television signal that supplement a brightness signal to represent a color.
7. Like any good manager, Goldmark most likely supplemented Air Force funds with CBS Laboratory resources.
8. Gene Smith, "C.B.S. Disk Report Pushes Stock Up: Trade Delayed as Brokers Tell Buyers of Denial," *New York Times*, Mar. 1, 1966, p. 1.
9. Ciba AG was formed in the 1850s as a silk-dyeing business and branched out into pharmaceuticals

in 1900. Ciba merged with J.R. Geigy SA to become Ciba-Geigy SA in 1970.

10. Goldmark, *Maverick Inventor*, p. 188.
11. *Ibid.*, p. 190.
12. *Ibid.*, p. 199.
13. "Electronic Video Recording and the Motorola Teleplayer," undated three-fold brochure; see <http://www.bretl.com/documents/MotorolaTeleplayeraccordionfold.pdf>.
14. EVR Partnership, August 1972, Terra Media Archives; see <http://terramedia.co.uk/media/video/evr2.htm>.
15. "E.V.R. Phasing Out Arranged by C.B.S.," *New York Times*, Dec 24, 1971, p. 44.
16. Brochures describing many these training cassettes are available at <http://www.bretl.com/EVRdocuments.htm>. This website also has many brochures and pamphlets prepared by CBS that describe the EVR system.
17. Much of the information in the Postlude can be found at: terramedia.co.uk/media/video/evr.htm

Acknowledgements

The Motorola participation in this EVR story was documented by five surviving Motorola engineers who came together in 1968 to take part in the EVR project. They reunited in 2017 to tell their tale.

- Senior Director of EVR Design Engineering, Albert "Bud" Massman
- Electrical Design Engineer, Wayne Bretl
- New Products Dept. Manager, James Sibbing
- New Products Dept. Engineer, Don Rust
- Quincy Plant Production Engineering Manager, Olin Shuler.

It has been an honor to serve as the scribe for the group. I extend my sincere thanks to each of them for their assistance in making this possible. Thanks also to AWA Review editor Eric Wenaas

for his guidance and support. Perhaps somewhere along the Eastern Seaboard (or elsewhere) there are retired executives or engineers from the CBS side of the equation, with an equally interesting EVR narrative from their viewpoints. History awaits its recording.

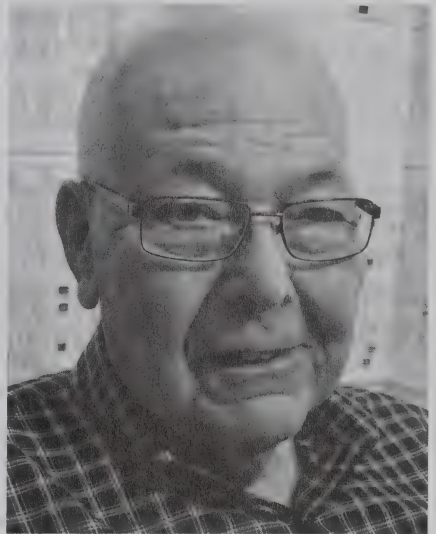
About the Author

Olin Shuler is a lifetime radio enthusiast, building his first radio at age 15. He has held FCC commercial and amateur radio licenses since the early 1950s. Years of radio manufacturing experience were gained at Motorola Inc. during its peak of home and auto radio production between 1950 and 1976 at the Quincy, Illinois plant. In its hey-day, the plant employed three to four thousand workers, and for a time was the world's largest active radio manufacturing facility.

As a production engineer, and later the department manager, he and his staff served as technical interface between design engineering in Franklin Park, Illinois, and the Quincy plant, 300 miles distant. The department was responsible for technology transfer and provision of ongoing support, performing services nowadays defined as that of a quality engineer. Each new project brought

learning opportunities for the people in a plant producing an increasingly diversified product line.

Today, Olin Shuler is a retired Registered Professional Quality Engineer (California License QE-5694), and a Fellow in the American Society for Quality, (ASQ). He is a past-president of the Antique Radio Club of Illinois, 2014 recipient of the Radio Club of America Link Award, and active in six antique radio organizations including ARRL and AWA.



Olin Shuler

Zeh Bouck, Radio Adventurer

Part 2: The *Pilot Radio* Brings Good Will to Central America

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Zeh Bouck (2PI, W8QMR) was an early radio pioneer and writer who helped design the Pilot Super Wasp and directed the company's aircraft communication efforts aboard their "flying laboratory," the *Pilot Radio*. In 1930, he, William Alexander, and Lewis Yancey accomplished the first flight from the U.S. mainland to Bermuda, demonstrating the value of continuous air-to-ground HF communications. An even more ambitious (and publicity-seeking) mission followed when Bouck, navigator Yancey, and pilot Emile Burgin set out to essentially circumnavigate the South American continent in a "goodwill flight." The rationale and logistics for this odyssey, and background information on related flights—including two by Charles Lindbergh and one proposed by another "radio adventurer," Donald Croom Beatty—are presented. The Pan Am radio system developed by engineer Hugo Leuteritz helped make it possible. Bouck's own accounts, other documentation, and information from government sources allow us to follow their journey from a meeting with the president in Washington, D.C., through aerial funeral duty in Mexico, a visit to U.S. Marine station NN1NIC in Managua, Nicaragua, and a stop at the Canal Zone, from where they would hop off for South America. Communications records were set along the way, and adventures were many on this Central American portion of their goodwill flight.

Introduction

In the Wake of Bermuda

They'd done it! On April 2, 1930, the *Pilot Radio*, a pontoon-fitted Stinson-Detroiter monoplane owned by the Brooklyn radio parts company of the same name, became the first plane to reach Bermuda from the U.S. mainland.¹ Radio pioneer, adventurer, and writer Zeh Bouck (born John W. Schmidt in 1901), along with pilot William Alexander and navigator Lewis Yancey, reached this "dot in the ocean" without the benefit of any radio beacon,

the GPS of its day. All along the way, Bouck kept up CW communications on 41 meters with WHD in New York using Pilot Radio equipment (including a modified Super Wasp receiver) that he had helped design and modify for aerial use. Their achievement added momentum to the push for commercial flights to prohibition-free Bermuda and gave Bouck an audience for his exciting first-hand accounts.

Although the flight did achieve "first" status, it wasn't non-stop, as originally planned. There were three

unscheduled water landings before their arrival at Hamilton Harbor, and Bouck had been on the verge of sending an SOS signal at least once. More importantly, it resulted in little publicity for the company. Instead of referring to Pilot Radio, newspaper accounts universally referred to it as "Yancey's flight" because of the navigator's fame the previous year in being the first, along with pilot Roger Q. Williams, to fly from the United States to Rome, where they had been swarmed by admiring throngs and decorated by Mussolini.

Worse yet, the *Pilot Radio* flight would soon be showily outdone. Yancey had somehow begun a friendly (or not) rivalry with Williams.² On June 29,

1930, the Bellanca monoplane *Columbia* piloted by Williams took off from Roosevelt Field on Long Island, flew non-stop to Bermuda, circled the islands, dropped a sack of mail including a letter to the Bermuda Governor from New York Mayor Jimmy Walker, then turned around and flew back for a complete non-stop round trip of just 17 hours and one minute.³ It carried no radio or emergency equipment, returned with fuel to spare, and, probably in an attempt to irritate Yancey as much as possible, the crew downplayed the difficulty of finding the islands.

In fact, their flight was not all that easy and smooth: the *Columbia* was nearly downed by a rain squall over Bermuda that bedeviled its magneto, and



Fig. 1. Pilot Emile Burgin, radioman Zeh Bouck, and navigator Lewis Yancey about to depart Roosevelt Field, New York, on their good will flight on May 14, 1930. (Author's collection)

was so fierce that it started to chip away at the aircraft's copper-and-wood propellers.⁴ Although the *Columbia* hadn't been forced down, it still landed Williams in water—of the hot variety. After the *Pilot Radio's* flight, which hadn't secured necessary permission from the Bermuda government, the authorities there had made it clear that any further unauthorized violations of their airspace wouldn't be tolerated. Although no guns were pointed in the *Columbia's* direction—Bermudians instead looked up to the sky and cheered—a formal protest of the flight was lodged with the U.S. State Department, and Williams's pilot's license was suspended for a time. Still, his flight seemed to run rings around the *Pilot Radio*. No doubt Williams put a notch in his belt.

But Yancey, Bouck, and the *Pilot Radio* were a few steps ahead of him. When news of the flight reached them, they, along with pilot Emile Burgin, were over 5,000 miles away in Buenos Aires, having flown nearly halfway around the perimeter of the enormous South American continent on a "Good Will Flight" (hereafter abbreviated as GWF). Fig. 1 shows the crew just prior to takeoff.

Background: Goodwill and Circumnavigations

The 1926 Pan American GWF

Some background information is needed to understand the *Pilot Radio's* GWF today. Between 1890 and 1925, the U.S. military had intervened somewhere in Latin America an average of once a year.⁵ In the States, this was

seen as necessary to protect American business interests like the United Fruit Company and to control the vital Panama Canal. South of the border, though, this "Big Stick" policy made the United States few friends, and it was costing increasing amounts of money and lives.

It seems odd, then, that one of the earliest gestures of American goodwill involved sending in the military . . . again. Five Army Air Corps planes embarked on a 22,000-mile "Pan-American Good Will Flight" that began in San Antonio on December 21, 1926. As shown in Fig. 2, they flew south through Mexico and followed a counter-clockwise course down the Pacific coast of Central and South America, crossing the Andes 500 miles south of Santiago, Chile, then proceeding north along the Atlantic coast and up through the Caribbean, finishing off in Washington, D.C., about five months later. The planes, referred to as "gas-burning doves of peace,"⁶ were open-cockpit Loening OA-1 amphibians that could set down on either water or land. They carried no radios or radio navigation equipment. The flyers, Army officers who were pilots and mechanics specially trained for this mission, were led by Major Herbert A. Dargue.⁷ The daring flight around the continent's perimeter was said to accomplish the "first aerial circumnavigation" of the South American continent, an amazing feat, although strictly speaking it had bypassed the difficult southernmost part that ended in Tierra del Fuego. And it came at a high price: a mid-air



Fig. 2. Commemorative poster for U.S. Army Pan-American Good Will Flight ("GWF"). Five Loeving amphibians accomplished what was essentially the first perimeter circumnavigation of South America in 1926. Two planes and two men were lost. (Smithsonian National Air & Space Museum, NASM USAF-A3568AC)

collision over Buenos Aires destroyed two of the planes and took the lives of two crewmen.⁸ Over the years other similarly ambitious attempts would continue to exact a death toll.⁹

Lindy Brings Goodwill—Twice!

In 1927 no one was more famous than pilot Charles A. Lindbergh, who had set his *Spirit of St. Louis* down in Paris after the first solo New York-to-Paris flight on May 21. Previously unimaginable fame and adulation followed. “I found myself symbolizing aviation. What I said and did was printed in newspapers all over the country, in addition to much I did not say and did not do. Invitations came from dozens of cities,” he recalled.¹⁰ Among these was one from Mexican President Plutarco Calles inviting him to visit Mexico City. With the Mexican Revolution and Pancho Villa’s raid on Columbus, New Mexico, still fairly recent memories, the new U.S. Ambassador there, Dwight Morrow, was looking for ways to improve relations and had solicited the invitation. Lindbergh, a congressman’s son and leading proponent for the growth of U.S. aviation, understood what was being asked of him. It was his hope “that the flight will show the way in which aviation brings the peoples of the world together.”¹¹

In his first GWF, he flew the *Spirit of St. Louis* directly from Bolling Field outside of Washington, D.C., to Mexico City’s Balbuena Airport, accomplishing the very first nonstop flight between those two capitals (see Fig. 3). As other invitations piled up he extended his

tour, flying over Central American jungles, mountains and volcanoes, then winging his way still further south through Columbia and Venezuela, returning to the United States via the Caribbean. Everywhere he went he was met by admiring crowds. Case in point: his reception in Tegucigalpa, Honduras. “He entered the capital as a conqueror above the need of troops to win the acclaim of the populace . . . With bands playing, flags flying and the streets festooned with colors, bridged with triumphal arches and strewn with pine needles, the Viking of the air rode with the President of the Republic . . . while children threw roses in the path of the car.”¹² The Honduran National

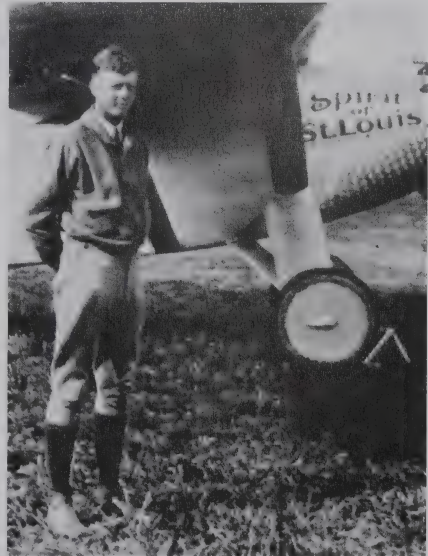


Fig. 3. Charles Lindbergh about to hop off from Bolling Field outside of Washington, D.C., on his initial GWF in December 1927. His arrivals generated widespread acclaim and publicity, inspiring a host of far less successful GWFs in decades to come. (Author’s collection)

Anthem and “The Star-Spangled Banner” were played, electric signs flashed “Welcome Lindbergh,” and a two-day holiday was declared.¹³ Julius Caesar would have been jealous.

Interestingly, the *Spirit of St. Louis* had carried no radio. At the time, Lindbergh “had concluded that aircraft radio equipment was not only heavy but excessively unreliable.”¹⁴ He would soon come to a different conclusion after beginning an association with a

new company called Pan American Airways and its founder, Juan Trippe. Both he and Trippe were dedicated to the expansion of air routes to Latin America and beyond, which Pan Am, with a little help from the U.S. government, would make happen.¹⁵ Pan Am had the good sense to study air-to-ground communications for its possible utility in long-range flights where “seat of the pants” visual navigation could not be relied upon and radio beacons



Fig. 4. Hugo C. Leuteritz, Chief Communication Engineer, Pan American Airways with one of the aircraft receivers he designed. (*Radio News*, Apr. 1931, p. 886)

were few and far between. To do this, they poached an engineer from RCA, which was also exploring the new field but so far hadn't been able to interest any company other than Pan Am.¹⁶

In August of 1928, Hugo C. Leuteritz (Fig. 4), a Navy-trained radio engineer, was welcomed aboard Pan Am's *General Machado*, a Fokker trimotor land plane, in Havana, Cuba, by a pilot who told him, "I've thrown better radios off airplanes than you can build."¹⁷ At that time, Leuteritz was on loan from RCA and had installed a 10W transmitter (that's right, ten whole watts!) on the plane (4XN), while Pan Am's Miami and Key West stations were both equipped with high-tech Radiola 28 receivers (Fig. 5), presumably modified for 2,000–3,000 kHz reception.¹⁸

A few hours later, the *General Machado* was lost and was low on fuel with no land in sight. Leuteritz advised Key West, but they had no facilities for radio direction finding and could not help. The plane had to be ditched into the Gulf of Mexico, killing one of its two passengers. Leuteritz escaped with minor injuries, and Pan Am sensibly ramped up its radio communication and radio compass efforts, hiring him to head the program. Pan Am would quickly become the leader in the field, with a growing list of pioneering airfields equipped with aero-radio facilities throughout Latin America, about which more will be said later.

Whether Lindbergh changed his mind about aircraft radio because of his association with Pan Am and Leuteritz

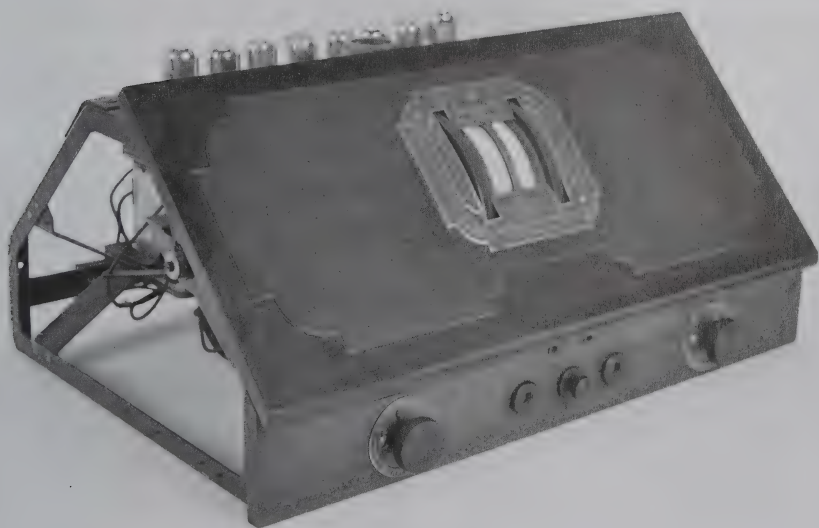


Fig. 5. RCA Radiola 28 receiver chassis, a modified version of which was used for reception at Miami and Key West Pan Am stations in the early days of their aircraft radio communication experiments. (Courtesy of Eric Wenaas)



Fig. 6. Pan Am founder Juan Trippe and aviator Charles Lindbergh in British Guiana during their 1929 GWF. (Lindbergh Picture Collection, Manuscripts and Archives, Yale University Library)

isn't known, but in 1929, when Lindbergh and his new wife (Ambassador Morrow's daughter Anne), Trippe with his wife, and two other crew members made a second GWF of about 7,000 miles around Latin America in a larger amphibious plane (see Fig. 6), they were in constant radio contact with ground stations, reporting their progress every half-hour.¹⁹ Besides bringing goodwill, they had explored Mayan ruins and, more importantly, scouted landing sites and possible air routes for future Pan Am flights. Although neither of Lindbergh's GWFs involved circumnavigations because they were limited to only northern South America, they helped make possible future commercial routes and radio facilities, some of which the *Pilot Radio* would later rely upon.

Still More Goodwill

In 1928, the new president-elect, Herbert Hoover, kicked off a policy of better relations with Latin American countries with a 10-week grand "Good Will" tour by sea (Fig. 7).²⁰ He came to spread word of his new non-interventionist policy that would later be called the "Good Neighbor" policy and would become associated with his successor. Other than an aborted assassination plot in Argentina, the reception he received was cordial, if not as enthusiastic as Lindbergh's.

Goodwill and circumnavigation, it should be noted, were not the exclusive provinces of *Nortamericanos*. In June of 1928, the young Mexican aviator Captain Emilio Carranza (Fig. 8), who had met and been impressed by Lindbergh,



Fig. 7. (Left) President-elect Herbert Hoover and an unidentified U.S. Navy Commander aboard the USS *Utah* off the coast of South America in 1928. Thirteen years later the ship was sunk by a Japanese torpedo bomber at Pearl Harbor, Hawaii, where it still remains a war grave. (Author's collection)

Fig. 8. (Below) Mexican aviator Emilio Carranza arrives in Washington, D.C., on his GWF from Mexico City in 1928. About a month later, Carranza lost his life flying through a thunderstorm in the New Jersey Pine Barrens while attempting to return to Mexico. (Courtesy of San Diego Air & Space Museum)



was elected to return Mexican goodwill to the United States.²¹ He flew his plane, the *México-Excelsior*, from capital to capital (Mexico City to Washington D.C., the reverse of Lindbergh's flight), making only one stop due to heavy fog. Proceeding to New York, he received the customary wining and dining with such glitterati as the ever-present Mayor Walker, President Calvin Coolidge, actor Charlie Chaplin, and boxer Jack Dempsey. A series of thunderstorms kept delaying his return to Mexico, until finally on July 12 he hopped off (the old term for "took off") from Roosevelt Field despite the foul weather. Shortly afterwards, the *México-Excelsior* crashed into the trees in the New Jersey Pine Barrens, either struck by lightning or flying too low in poor visibility conditions while trying to find a place to land.²² His loss was mourned in both countries and a monument to his bravery and the Pan-American goodwill he symbolized stands to this day at the crash site outside of Tabernacle, New Jersey.

Later in 1928, two Peruvian aviators tried for a South American circumnavigation that was considerably more difficult than the successful 1926 U.S. Army GWF in that it used a land plane. Many of the Army Air Corps landings were possible only because the planes that were used could also land on water. On December 11, 1928, Captain Carlos Martínez de Pinillos Coello (Fig. 9) and first lieutenant Carlos Zagarra Lanfranco hopped off from Lima in their Bellanca CH-300 monoplane, *Perú*, flying counter-clockwise around



Fig. 9. Peruvian Captain Carlos Martínez de Pinillos Coello, who, along with Lt. Carlos Zagarra Lanfranco flew their plane, *Perú*, on a GWF through much of South America and as far north as New York City in 1928-9. (Courtesy of Guillermo Pinillos)

the continent, with plans to bring their southern goodwill as far north as New York City before completing the giant circle. The flight went according to plan for about 7,000 miles, then ran into difficulties after landing near Belém in Brazil. Unable to hop off, the *Perú* had to proceed to the United States by steamship, after which it successfully completed another 6,000-mile multi-stop aerial arc back to Lima.²³

Goodwill was brought to fellow Latin Americans about six months



Fig. 10. Mexican aviator Colonel Pablo Sidar, who flew some 26,000 miles through Latin America and the Caribbean on a GWF in 1929, and in whose funeral cortege the *Pilot Radio* participated the following year. (By permission of Fideicomiso Archivos Plutaraco Elias Calles y Fernando Torreblanca, FAPECF)

before the *Pilot Radio* GWF by the head of the Mexican Army Air Service, Colonel Pablo Sidar (Fig. 10), who flew the Douglas O-2M single-engine *Ejército Mexicano* (Mexican Army) airplane a staggering 26,000 miles throughout Central and South America and parts of the Caribbean. Known for his der-ring-do, Sidar and an Army mechanic hopped off from Mexico City on August 29, 1929, on a marathon tour of Central and South America, during which they crossed the Andes five times. On their way back, an emergency landing in Ecuador spared the plane and flyers but wrecked their engine.²⁴ After a delay of several weeks, during which the engine was replaced, they resumed their GWF through Central America and Cuba, and they received a hero's welcome back in Mexico City on November 8th. As extensive as their tour was, they had eliminated the northeast quadrant of the South American circle by heading inland mid-continent. So although the flight was not quite a perimeter circumnavigation, it was certainly a *tour de force* of Latin American aviation. And as we will see, Colonel Sidar would later play a role—although not one he would have chosen to play—in the *Pilot Radio* GWF.

One GWF that never happened is still worth noting. Like Zeh Bouck, Donald Croom Beatty (1900–1980) truly deserves the title “radio adventurer” and is a figure ripe for historical rediscovery (see Fig. 11). Beatty was an early radio pioneer and operator also noteworthy as an inventor and commercial pilot who understood the



Fig. 11. Pilot, engineer, inventor, and explorer Donald Croom Beatty in 1935. Although his proposed South American Trade Extension Flight fell victim to the Great Depression, Beatty went on to explore the Amazon and fly “the Hump” over the Andes. (Courtesy of Mary Alice Beatty Carmichael)

importance of air-to-ground communications. At some point he foresaw the opportunities that might await him much further south than his native Alabama. According to his wife, Mary Alice, “he wanted to explore, by air, the vast regions of the Amazon basin and the Andes that were marked on the maps as UNKNOWN, those vast regions where no expedition had ever been (and returned). He wanted to fly over the Andes and over jungles where no plane had ever flown (and returned). He vowed he would have his own airline across the continent of South America.”²⁵

To make a start of it, in 1929 Beatty organized and drummed up support for a “South American Trade Extension Flight” that would bring goodwill along with word of the benefits of U.S. trade to 34 Latin American countries during a six-month tour beginning in South Florida and proceeding clockwise around the entire continent.²⁶ The flight was backed by the American Manufacturers’ Export Association, which included luminaries from International Business Machines (none other than Thomas J. Watson), International Harvester, and other major concerns. But a crash brought the flight down even before it could even take off—the crash of the U.S. stock market in October of 1929. Remarkably, Beatty, later drawn into the Pan Am Latin American aero vortex as a pilot and then an executive, would still go on to achieve some of his goals in a series of adventures that included an encounter with *real* (not corporate) head hunters. The South American Trade Extension

Flight was permanently grounded, but its spirit may have lived on at Pilot Radio in Brooklyn, which, with much less capital than IBM and International Harvester, remained in business, and with sales of radio parts and kits still increasing, seemed surprisingly depression-resistant.

Flight Plans

When?

A close look at the *Pilot Radio* at the time of its historic Bermuda flight (April 1–2, 1930) reveals something odd. The Pilot logo painted on the side of the plane is surrounded by the words “South American Good Will Flight” (see Fig. 12). Bermuda pilot William Alexander’s and Zeh Bouck’s names are painted on the plane, while that of Yancey, who navigated it to Bermuda as well as on its GWF, is not. But at that time, there had not been any South American flight, and there never would be one with the crew as listed. Some explanation is in order.

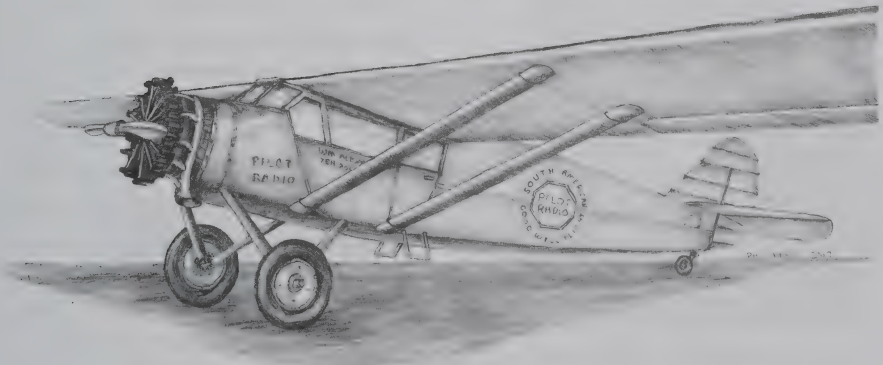


Fig. 12. The *Pilot Radio* as it appeared in March 1930 before either the Bermuda trip or the South American GWF had taken place. (Artwork by Phil Krejci based on assorted photos)

To make a long story short, in December of 1929, Yancey had announced his intention to fly roundtrip to Bermuda with pilot Emile Burgin, whom he had flown with before, but no plane or sponsor were specified.²⁷ This never happened. The following month Pilot Radio started spreading the word that their namesake plane, manned by Alexander and Bouck (but not Yancey), would make a 22,000 mile, 2–4 month long “goodwill” tour of Central and South America starting on March 25.²⁸ That didn’t happen either.

What did happen? On April 1–2, the *Pilot Radio* flew to Bermuda with pilot Alexander, radioman Bouck, and navigator Yancey. Either Yancey’s flight to Bermuda with Burgin with another plane/sponsor fell through, or Alexander for some reason replaced Burgin as pilot for Bermuda, while Bouck and the *Pilot Radio* had always been part of the plan. Either way, Pilot Radio chalked in the proposed 700-mile Bermuda trip before their even more ambitious South American sojourn. This allowed Bouck to be freed up as full-time radioman, and it would provide a 700-mile reality

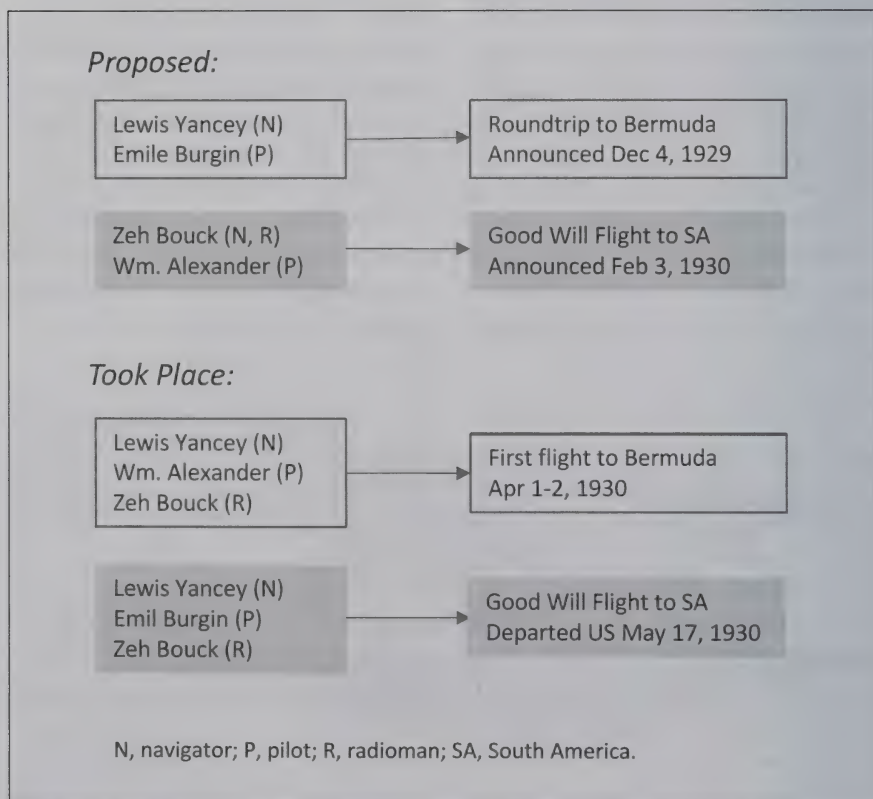


Fig. 13. Proposed and actual *Pilot Radio* flights 1929–1930.

check before the proposed 22,000-mile trip. Other factors (delays in getting South American landing permissions and arrangements for fuel) may have also been involved. Whatever the reason, the Bermuda trip went first, bringing Yancey as navigator. When it was over, the more ambitious GWF was given the green light. All of this is summarized in Fig. 13.

Who?

Much of the foregoing is educated guesswork, but Bouck himself explained why Alexander was replaced as pilot for the GWF.²⁹ On April 29, 1930, having returned from Bermuda several weeks earlier, Bouck was in his office when Yancey stopped by. Bouck told him, “Lon, I am having trouble with my pilot. I can take care of the trouble myself, but if I do so I am afraid the relationship between the pilot and myself will be somewhat strained and going on a long flight, such as a flight to South America, is going to be rather unpleasant.” His pilot, of course, at that time was William Alexander. Sadly for us, Bouck didn’t go into details on his “trouble” with Alexander.

Bouck asked Yancey to come with him to the office of Pilot Radio president Isidor Goldberg to request that Goldberg “get this pilot up on the mat and lay the law down to him.” He wanted Goldberg to discipline Alexander in Yancey’s presence without firing him, apparently so that Alexander would blame it on Yancey—who, at that point, wasn’t scheduled to be on the South American flight—rather

than him. This seems a little devious and, worse, unlikely to work. But with Yancey backing him up at Pilot Radio headquarters at 323 Berry Street, Bouck told Goldberg that Alexander had been “insubordinate in several ways” and asked him to “tell him where he gets off and make him behave himself.” On hearing this, Goldberg got “very angry indeed, and fired the pilot on the spot.” All of which led to Goldberg’s question about the upcoming GWF: “What are you going to do for a pilot?” Bouck responded, “Burgin has been with us before. He knows the ship and can make a very good job of it.”

Emile Henri Burgin, pictured in Fig. 14, was born in 1889 to parents who had emigrated from the Alsace.³⁰



Fig. 14. Emile H. Burgin, WWI veteran, barn-stormer, wing walker, and pilot of the *Pilot Radio* GWF, known to his fellow aviators as Eddie “Hard Luck” Burgin. (Author’s collection)

He grew up in New York City's Hell's Kitchen. Although rejected by the Army as an Air Corps volunteer in World War I and assigned to the infantry instead, his ambitions remained ever upward. After the war, he took flying lessons, bought himself a "Jenny," and earned a living the hard way as barnstormer, wing walker, and test pilot. He had flown with Yancey in a cross-country air race,³¹ and with "bad boy of the air" Bert Acosta. He'd also piloted a "flying laboratory" for another company with a familiar name in 1920s radio, Splitdorf.³² Among his fellow aviators, he was known as Eddie "Hard Luck" Burgin. Bad things had happened to him through no fault of his own, including mechanical problems at the start of one air race, a forced landing caused by bad weather near the end of another, and two different planes flipped on their backs by sudden gusts of winds *on the same day* while attempting to take off.³³ In the end, though, his skill would prove more notable than his hard luck.

When Burgin's name came up, Goldberg suggested that both he and Yancey should accompany Bouck on the trip. Yancey agreed to this. Bouck, however, had second thoughts about flying with Yancey again. He told him later that day that he had called Goldberg and said "that I did not think it desirable to have you [Yancey] on the flight . . . It would be a Yancey flight rather than a Pilot Radio flight. After all, Lon, the *Pilot Radio*—there is no getting away from this—is out to get publicity from this flight. You know what happened with the Bermuda flight,

which instead of being a Pilot Radio flight was a Yancey flight—not that it is your fault alone, but it just turned out that way—and I told Mr. Goldberg that I thought the same thing would occur in the South American flight." Dropping Yancey was okay with Goldberg, but Burgin wouldn't buy in without him: "It is absolutely impossible; if Lon doesn't go I don't go." This may have been solely out of loyalty to Yancey, but another possibility is that neither Burgin nor Alexander before him was willing to make such a long and dangerous trip accompanied only by one man with limited flying, navigational, and mechanical repair experience. And it wouldn't have escaped their attention that Bouck also had a physical handicap (despite which he was apparently able to fly a plane, as discussed in Part 1). Whatever the reason, Burgin stuck to his guns. The crew would be Burgin, Bouck and Yancey. And Bouck's prediction would come true: it would end up being "Yancey's flight" all over again.

How?

As described in Part 1 and documented on its license reproduced in Fig. 15, Pilot Radio's "flying laboratory" was a then-modern 6-seat Stinson SM-1F "Detroitter" high-wing monoplane registered with the special N number NR 487H. It was powered by a 9-cylinder, 300 horsepower Wright "Whirlwind" J-6 engine and had brakes by Harley Davidson. It had been modified by removing a seat to allow a radio unit to be installed, and by the addition of tanks in the wings to increase fuel capacity. Both

Form AB-8f UNITED STATES OF AMERICA
DEPARTMENT OF COMMERCE
AERONAUTICS BRANCH

SPECIAL No
NR-487M

SPECIAL AIRPLANE LICENSE

THIS CERTIFIES, That the airplane described in the margin and owned as follows:

RECORDED OWNER **PILOT LABORATORIES INCORPORATED**

BROOKLYN N Y

is a specially licensed aircraft of the United States of America for the following purpose: **RESTRICTED FOR RADIO EXPERIMENTAL WORK**

and assigned the special number indicated above.

Unless sooner suspended or revoked, this license expires **NOVEMBER 1 1930**

Director of Aeronautics

Description of Airplane

Model **STINSON**

24-1P

Mfg. No. **519**

Eng. Type **WRIGHT 300**

Seating Capacity **2**
(Exclusive Pilot & Crew)

NOTE:—All provisions of the Air Commerce Regulations are made a part hereof as though written herein.

PERSONS AND PROPERTY ARE NOT TO BE CARRIED FOR HIRE OR REWARD.

THIS LICENSE MUST BE PROMINENTLY DISPLAYED IN THE AIRPLANE.

In event of sale, this license is VOID and must be immediately returned to the Aeronautics Branch, Department of Commerce. See reverse side for full directions.

Fig. 15. Special airplane license for the *Pilot Radio* issued in 1929. (Federal Aviation Administration)

fuel and oil could be added from inside the plane. The plane's top speed was 135 mph and it could fly as high as 17,000 feet—high enough to cross the Andes. Well in advance of the trip, the octagonal "Pilot Radio Good Will Flight" logo had appeared on its sides. The plane was painted red and black with yellow wings, "looking much like a tropical bird."³⁴

By 1930, the utility of aircraft communications was becoming evident. Radio could be used to "keep the pilot informed as to changes of weather along his route; to get the position of the plane either by means of bearing observations in the airplane or on the ground; to follow a definite course as marked by a radio beacon; to obtain information as to landing conditions at the airport; to send and receive traffic

dispatches while in the air, and to call for aid in giving the airplane's position should an emergency landing be necessary."³⁵ For all of these reasons and more, the *Pilot Radio* carried transmitters and a receiver built by its namesake company and modified by Bouck.

The setup was a slightly improved version of the one used in the Bermuda flight. The receiver was an AC Super Wasp regenerative set modified to use heavy-filament Arcturus AC tubes and had plug-in coils to cover 14 to 1200 meters. The main transmitter, which would be used for CW and voice communications between 25 and 60 meters, had been changed from a self-oscillator to a master oscillator power amplifier (MOPA) "with a 210 tube pushing a UX211." Using one of two plug-in coils, this delivered 60 to 70

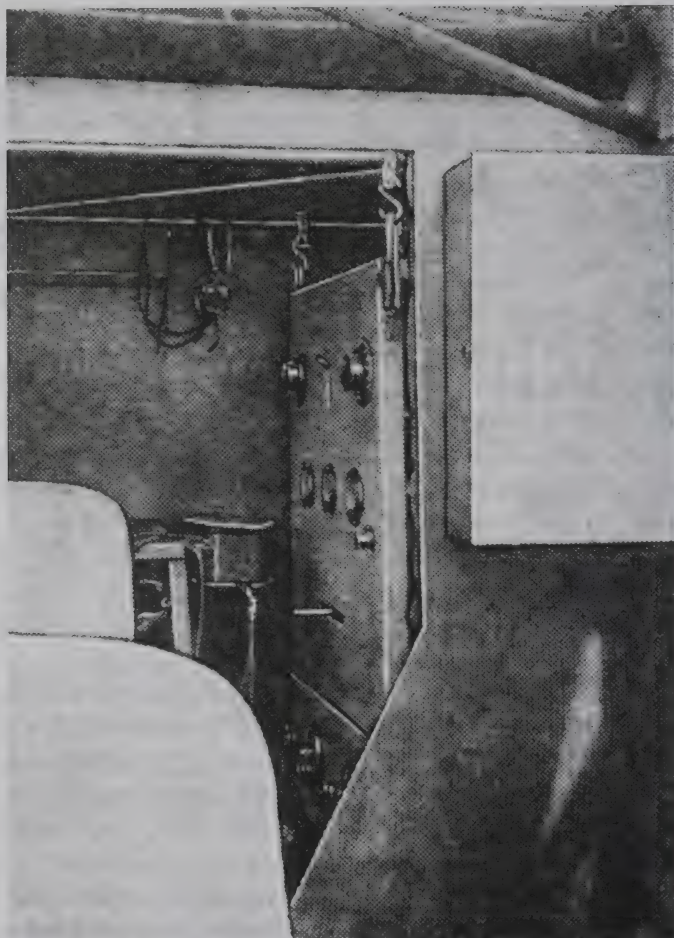


Fig. 16. Radio room of the *Pilot Radio* during its 1930 GWF. (*Radio News*, Feb. 1931, p. 734)

watts to the trailing-wire antenna.³⁶ Most likely, the key MOPA advantage was reduced “frequency wobble” due to movement in the streaming, wind-exposed antenna.³⁷ Also for this trip, the 210 and 211 triodes may have been specially evacuated to handle high plate voltages by Eveready-Raytheon, one of the flight’s sponsors.³⁸ A second transmitter for the traditional 600-meter

marine emergency frequency was also included. Both transmitters and the receiver were shock mounted to the plane’s frame (see Fig. 16). All filament voltages were supplied by an Exide “non-spillable” 12-volt lead-acid aircraft battery, which also fed a dynamotor that provided plate voltages to the transmitters. Receiver B and C voltages were supplied by Eveready batteries. The

storage battery was constantly charged (except when transmitting) by a wind-driven generator. For most purposes, about 90-feet of trailing-wire antenna was used to work the third harmonic on 41 meters. The metal frame of this plane covered with doped canvas served as the counterpoise ground. An antenna could be strung up on the ground in an emergency, but would of course have a more limited range. The effective weight of the apparatus was 130 pounds. The plane was given the call signs W2XBQ (U.S.) and LU4A (Argentina). Bouck would be at the mike and pounding brass using International Morse code, with which he was just as proficient as American Morse, his first code.

Where?

As originally proposed, the *Pilot Radio* GWF would be a 22,000-mile odyssey that would hop off from Roosevelt Field in New York on March 25, 1930, and take 2 to 3 months.³⁹ Leaving New York bearing letters from Mayor Jimmy Walker to the heads of South American cities (no doubt extending his personal invitation to visit the Big Apple), their first stop would be Washington, D.C., to pick up more goodwill letters from President Hoover himself and the Pan-American Union, predecessor of the Organization of American States (OAS). Collectively, the superabundance of goodwill letters might make the flight seem like a long airmail run.⁴⁰ Perhaps the cumulative force of all this goodwill could float the plane skyward without even starting the engine!⁴¹

From Washington, D.C., they planned to fly to Atlanta and then Miami. A 90-mile, over-water flight to Havana, Cuba would follow. Another over-water flight would bring them to Mexico. Tracing the coast of the Yucatan Peninsula, they would stop at Vera Cruz and Mexico City. From there to Buenos Aires, their route would mostly be similar to that flown by the U.S. Army Good Will Flight (see Fig. 2). Heading southeast, they would then refuel in Guatemala City and fly on to Managua, Nicaragua. The Canal Zone in Panama would be their final stop in Central America.

Possibly the most difficult leg of their flight would follow: crossing the Gulf of Panama, they would head south to Buena Ventura in Columbia and then fly down to coastal Guayaquil in Ecuador, "twelve hundred miles of cliff-bordered coast, with impassable mountains on the left." From there, the plan was to continue south along the Pacific coast of Peru (Talara, Trujillo, Lima, and Arica) and Chile (Antofagasta and Santiago). The *Pilot Radio* would then turn east and hop over the spine of South America, the high Andes, to reach Mendoza, Argentina. Further east, they would stop in Buenos Aires in time for the Radio Exhibition on May 1. A short trip to the capital of Uruguay, Montevideo, would follow, after which they would head mostly north, stopping at São Paulo and Rio de Janeiro in Brazil.

From Rio, their plans were less certain. Under the most frequently discussed scenario, they would continue

their long journey north through less-developed regions of the Atlantic Coast, stopping at Vitoria and at Natal, at the eastern tip of the continent. From there the details become especially hazy, but the plan was probably to continue on a more-or-less coastal route to Guyana (home of the notorious prison, Devil's Island) and to arrive back home by essentially island hopping across the Caribbean. But under an alternative scenario, from Rio the flyers would partly disassemble the *Pilot Radio* and return to New York with it by steamer as they had done from Bermuda.⁴² Interestingly, either way, after their return Yancey and Burgin (but possibly not Bouck) planned to fly the *Pilot Radio* from New York to Moscow.⁴³

Why?

At least four different reasons for making the flight were proposed: to promote goodwill, to demonstrate the utility of radio equipment on long-distance flights, to develop interest in radio in connection with aviation, and to establish new air routes.

1. "To promote commercial good-will between the two great continents of the Western Hemisphere,"⁴⁴ thus furthering amicable trade relations:

This surfeit of goodwill might just take the form of increased Pilot Radio sales, and in particular, Pilot Super Wasp sales abroad, where the company already did a considerable percentage of its business. A May 1929 stock offering notice reported that it sold 40% of its products in Europe, Africa, South

America, and Asia, and a February 1930 news article noted that "Pilot does a large business in South America."⁴⁵ In fact, Goldberg employed his half-brother Emanuel Goldberg (referred to within Pilot and in *Radio Design* articles as "E. Manuel" since there could be only one "Mr. Goldberg") to manage company sales in Brazil and probably the rest of Latin America.⁴⁶ The original flight plan called for the flyers to meet up with Manuel in Rio.

A stop at the Radio Exhibition in Buenos Aires was also originally scheduled. Public exhibitions featuring the miracle of radio, such as the 1922 Brazilian National Centennial Exposition in Rio for which Westinghouse had set up a transmitter on Mount Corcovado, had played a big part in generating enthusiasm for radio sales and radio broadcasting in South America. They had proven far more effective than earlier attempts to set up foreign-owned radio networks like that of one company that failed despite its curiously futuristic name, Amazon Wireless.⁴⁷ What worked once should work again, and in-flight broadcasts to the people of Buenos Aires from the *Pilot Radio* would, in fact, be made, though too late for the Radio Exhibition.

Notably, like the defunct South American Trade Extension Flight by Beatty, the *Pilot Radio* was originally supposed to carry American-made trade goods like cameras, guns, spark plugs, etc. to wow local business representatives with the quality of U.S. manufacture.⁴⁸ The goods would need to speak for themselves since it appears

that neither Burgin nor Bouck nor Yancey could speak fluent Spanish. But since no mention of this appears later, it is safe to assume that no such traveling display made the journey —unless one considers the plane and the necessary equipment it carried. Back in the United States, however, it was hoped that goodwill and sales would accrue to Pilot Radio from extensive domestic coverage by papers like the *New York Times*, which had, after all, given both of Lindbergh's GWFs wall-to-wall coverage.

2. *For the purpose of radio experimentation, which was expected "to demonstrate beyond argument the utility of such apparatus [radio equipment] on long distance air flights."*⁴⁹

The *Pilot Radio* would carry out experiments to determine the limits of routine communications between planes in flight and stations on the ground at shortwave frequencies, a concept that wasn't totally new but hadn't yet been universally adopted. Radio communication with stations all along the way would prove important to the success of the flight, mostly for their reports about weather and visibility. Attempts to set showy new records for long-distance air-to-ground communications

(e.g., the world's longest air-to-ground telephone call) would be made, and would prove successful. Just how much this would influence attitudes about aircraft radio, though, is debatable.

3. *"To create and develop interest in radio communication in connection with aviation."*⁵⁰

Isidor Goldberg, President of Pilot Radio (Fig. 17), conveyed the idea of developing interest in communication in connection with aviation in a letter to Mr. George Akerson, Secretary to President Herbert Hoover. This might have indicated that Pilot really was serious



Fig. 17. Isidore Goldberg, President of Pilot Radio. (Alan Douglas collection)

1-28
PREPARING OFFICE
ALL INDICATE WHETHER

1-48
TO BE TRANSMITTED
CONFIDENTIAL CODE
NONCONFIDENTIAL CODE
PLAIN

TELEGRAM SENT

Department of State

Charge to
Pilot Radio and Tube Company,
323 Berry Street,
Brooklyn, New York.

Washington,
May 17, 1930.

Pilot Radio and Tube Company,
323 Berry Street,
Brooklyn, New York.

Permission for flights over Guatemala and Nicaragua
granted.

Henry L. Stimson
Secretary of State:

810.79611 North American
Aviation Co./5

LA:JFM:G:GNC
msh. WCH

May 17 1930
TELEGRAPH
MAY 17 30

Enciphered by
Sent by operator
Lester B. - Div. 20

SW04013

810.79611 NORTH AMERICAN AVIATION CO./12

Fig. 18. Record of text of a telegram from the U.S. State Department to Pilot Radio informing them that Guatemala and Nicaragua flyover permissions have been granted. Message bears the signature by or on behalf of Henry L. Stimson, who was Hoover's Secretary of State and would later become FDR's Secretary of War and oversee the Manhattan Project. (U.S. Department of State)

about getting into aircraft radio or—less plausibly—that it was unselfishly proposing to promote aircraft radio sales by other companies. More likely, it was an attempt to solicit as much support and goodwill as possible toward the

company from the Hoover Administration. Goldberg certainly knew that the president formerly regulated U.S. radio as Commerce Secretary, that he had made his own Good Will Tour of South America (by sea), and that his

son Herbert Hoover Jr., an amateur radio operator who would eventually become the president of ARRL, was an executive at Aeronautical Radio, Inc., where he oversaw the purchase of radio equipment.⁵¹ Goldberg wasn't averse to having friends in high places. And as for immediate needs, he knew that U.S. State Department help was required to get the necessary fly-over and landing permissions from foreign governments. In fact, documents regarding these requests would bear the signature of Henry L. Stimson (see Fig. 18), future secretary of war and overseer of the Manhattan Project, although they were probably signed on Stimson's behalf.

President Hoover would meet briefly with Goldberg and the flyers in Washington as they headed south, but other than help with permissions and a few words of encouragement, the administration's support seems limited. The *Times* and other publications repeatedly stated that the flight was sponsored by the Hoover administration as well as by American diplomats and business interests,⁵² but a search of U.S. State Department and White House records turned up a small number of documents that do not bespeak a major commitment. Associating too closely with largely unknown parties was politically risky,⁵³ and besides, by 1930 Herbert Hoover had other things on his mind.

4. "To establish a new airway particularly adapted to the requirements of land planes."⁵⁴

Establishing new airways shouldn't necessarily bring to mind a picture of

Burgin and Bouck hacking out runways in the jungle with machetes while calling up to Yancey, "Lon, are you done with that control tower yet?" After all, Lindbergh, even on his solo goodwill flight, was credited with "blazing a new air trail." Actually developing a new commercial air route was a major effort involving many people with many different skills. One first step in establishing a route from point A to point B was an aerial survey noting potential landing and emergency landing sites, obstacles, weather, etc.⁵⁵ It was a stretch to say that *Pilot Radio's* flight would do much of this, but it made for good press.

One fact that most U.S. readers would not have known is that by 1930 nine different airlines, including Pan American Airways and the French carrier Aéropostale, plied their trade over 32,000 miles of scheduled routes in South America, flying some 315,000 miles per month and making a profit doing it, mostly carrying airmail but also passengers.⁵⁶ Pan Am, through its joint venture Panagra, had routes from Panama to Santiago, Chile, along the west coast of the continent for most of the route that the *Pilot Radio* would take, while the same was true for Aéropostale (later to be subsumed into Air France) along the east coast of South America. Using existing commercial routes, anyone who could afford it could, for example, have a "high time" flying 14,000 miles and visiting 20 Latin American countries, as publisher William H. Gannett did in early 1930.⁵⁷ In fact, the *Pilot Radio* would depend on the fuel, mechanics, and facilities

available at many established Pan Am and Aéropostale airports, as had Colonel Sidar's earlier GWF. So what would be so special about the proposed *Pilot Radio* GWF?

Many commercial South American flights were possible only via planes able to land on water, which explains why most existing routes were coastal rather than inland. For the GWF, the *Pilot Radio* would have only wheels, not pontoons, so water landings equaled death. In some places there were few or no established airfields, much less emergency landing sites, so suitable sites would need to be found. Commercial flights generally used multi-engine planes; the *Pilot Radio's* crew would stake their lives on a single Wright J-6 engine over a distance nearly equal to the circumference of the Earth. Few good maps existed—Lindbergh, for example, had used one torn out of a tourist brochure—and *Pilot Radio* crew would need to “feel their way” over the unfamiliar landscape at times. Some parts of the proposed flight, such as crossing the often-stormy Gulf of Panama and the passage over the high Andes, are not without hazard even today. Weather could turn vicious without warning, and tropical static could make radio communications impossible. Hurricanes were always a hazard and much less predictable than now. In fact, a Category 4 hurricane (San Zenon) would devastate parts of the Dominican Republic, killing more than 2800 people, just days before they made their way back through the Caribbean.

And there was one danger that, oddly, was never mentioned: the possibility of being shot down, or just shot. Unlike peaceful, friendly Bermuda, wars and revolutions were underway in some Latin American nations. Some of these employed airplanes supplied overtly or covertly from North America. “Several major skirmishes during the South American revolts of 1930 were aided by use of aircraft which routed ground forces of the opposing army.”⁵⁸ So in Latin America, “local *caudillos* (warlords) would view with supreme suspicion any Yankees purporting to be transiting their national borders in aircraft on the grounds of a Good Will Flight.”⁵⁹ The *Pilot Radio* would have official permissions, but commanders in the field might not know or care. And for rebels, government permission would be an open invitation to open fire. Getting a shoot-first-and-ask-questions-later reception or having their plane commandeered were real possibilities. Just in case their goodwill wasn't always reciprocated, the GWF crew did pack a few guns.

All in all, by today's standards the *Pilot Radio's* GWF verged on foolhardiness, but even by 1930 standards it was gutsy. There was no guarantee that Bouck, Burgin, and Yancey would come back alive. In fact, they almost didn't.

The *Pilot Radio* GWF⁶⁰

North America: The White House

Problems with battery charging had delayed their Bermuda hop-off the previous month, so this time the flyers

were taking no chances: radio preparations for the GWF were completed the night before. Pilot Emile Burgin, Bouck, and Arthur Lynch (aero radio enthusiast and editor of *Aero News & Mechanics* and *Radio News* among others) took off “into the dazzling glare of floodlights” at Roosevelt Field, Long Island, around midnight on May 13, 1930. Bouck and Lynch did the final in-flight adjustments, ensuring they could communicate with *New York Times* radio station WHD as they had all along the Bermuda flight. Just as they were about to land, someone turned off the field lights. The blind, hard landing caused the plane to “bounce ecstatically in the air after the art and manner of an impressionistic dancer.”⁶¹ Luckily, plane and flyers were unharmed, though a few airfield personnel may have suffered being yelled at.

At 7:35 the next morning, a Wednesday, the *Pilot Radio* began its long odyssey, its big 300 hp engine speeding it down the Roosevelt Field runway, overcoming gravity and lifting it up into the clouds. Along with radioman Bouck, pilot Burgin, and navigator Yancey (Fig. 19), this first leg of the journey included a passenger: Isidor Goldberg, President of Pilot Radio. Another plane, the *Aloha*, carrying

Bouck’s wife Charlotte, Mrs. Yancey, and a news photographer flew alongside them for a while. Then, with a wiggle of its ailerons to signal goodbye, it turned off. After a few hours of flying through bad weather the *Pilot Radio* touched down at Anacosta Field in Washington, D.C., the city where the Pan American GWF had ended and Lindbergh’s first GWF had begun.

Accompanied by the U.S. representative for New York’s 10th Congressional



Fig. 19. Navigator Lewis “Lon” Yancey and pilot Emile “Eddie” Burgin with the *Pilot Radio* just prior to the GWF. (Author’s collection)

District (which included Brooklyn), Emanuel Celler, his daughter, Bouck, Burgin, Yancey, and Goldberg met with President Hoover in the White House (see Fig. 20).⁶² Yancey asked Mr. Hoover if he had ever flown or planned to fly. The answer was no. It was apparently a rule at the time that U.S. presidents needed to travel by safer means, which seemed a bit ironic to Bouck in light of the Commerce Department's efforts to promote air travel. They all shook hands with the president, who wished them well. Mr. Goldberg went back to New York to attend to Pilot Radio

business, while Bouck, Burgin, and Yancey attended to theirs.

A stop in Atlanta had been part of the original plan, but instead Jacksonville, Florida, was their destination the next morning. "Battling headwinds all the way down," they arrived about seven hours later, "arriving too late to push through to Miami." Bouck was in touch with WHD in New York the whole way, and would remain in touch for much of their voyage, relaying observations from Yancey, who was being paid as a *Times* correspondent. The next day, May 16, Bouck called the Miami station



Fig. 20. On the White House steps, May 14, 1930. Left to right: Jane Celler, U.S. Congressman Emanuel Celler, Zeh Bouck, Emile Burgin, Isidor Goldberg, Lewis Yancey. (*Radio News*, Jan. 1931, p. 588)

while in flight to inform them of their ETA and to schedule a plane wash for that afternoon.⁶³ They soon touched down at Pan American field. There the plane, its recently overhauled engine, and its radio equipment were double checked.

As previously mentioned, Pan Am was the leading proponent for and early adopter of air-to-ground communications. Each of its flights was equipped with a 12-watt transmitter with a range of up to 800 miles, and it had aboard a dedicated radiotelegraph operator with a "first class ticket" who would be in CW communications with one or more of its dozens of ground stations throughout Latin America, regularly sending and receiving weather reports and other vital information. At Pan Am ground station transmitters, the 200-watt output of a UV-204A triode with about 3 kV on its plate fed a doublet antenna.⁶⁴ Its power supply used two UX-866 half-wave mercury rectifiers.⁶⁵ In the many places where there were no power lines, gasoline-powered generators were used. Communications with these Pan Am stations would play an important part in enabling the *Pilot Radio* to circumnavigate a continent. On Monday, May 19 the *Pilot Radio* hopped off from the hard coral runway in Miami and left North America, never to return.

Cuba and Central America: A Funeral and a Near-Funeral

Their flight the next morning took them over the Florida Keys at 4,000 feet in fine weather. Between Miami and

Havana they kept in touch with WHD, New York on 25 meters, which, at 1,400 miles, was said to set a record at the time.⁶⁶ They soon landed at the General Machado Airport in Havana. As with the Pan Am aircraft that had crashed at sea with radio engineer Hugo Leuteritz aboard, this airport was named after General Gerardo Machado, a hero of the Cuban War of Independence and Cuba's increasingly dictatorial *Presidente* at the time. When they landed in Havana, a civic delegation welcomed them and "felicitated them upon their mission." The weekend they spent there included a meeting with Ambassador Henry F. Guggenheim, a pilot himself, and further felicitations at the famous "Sloppy Joe's Bar," a favorite hangout for Prohibition-era American tourists.⁶⁷

Monday morning saw the *Pilot Radio* taking off on a seven-hour nonstop flight to Merida (see Fig. 21), which was located in Mexico's Free and Sovereign State of Yucatan. Leaving Havana, they ran into "a bad haze" but radio communications with Pan Am station CZ in Cozumel, and later, station MY in Merida, assured them that clear skies were ahead. After they crossed 200 miles of Gulf waters conditions did improve, and they spotted the Yucatan prairies ahead. It was "one of the most desolate and arid stretches I have ever seen. The heat fried up from the ground in definite waves that registered on our oil temperature and in the severe bumpiness of the flight." After overnighing in Merida, they flew on through bad weather that again, as they

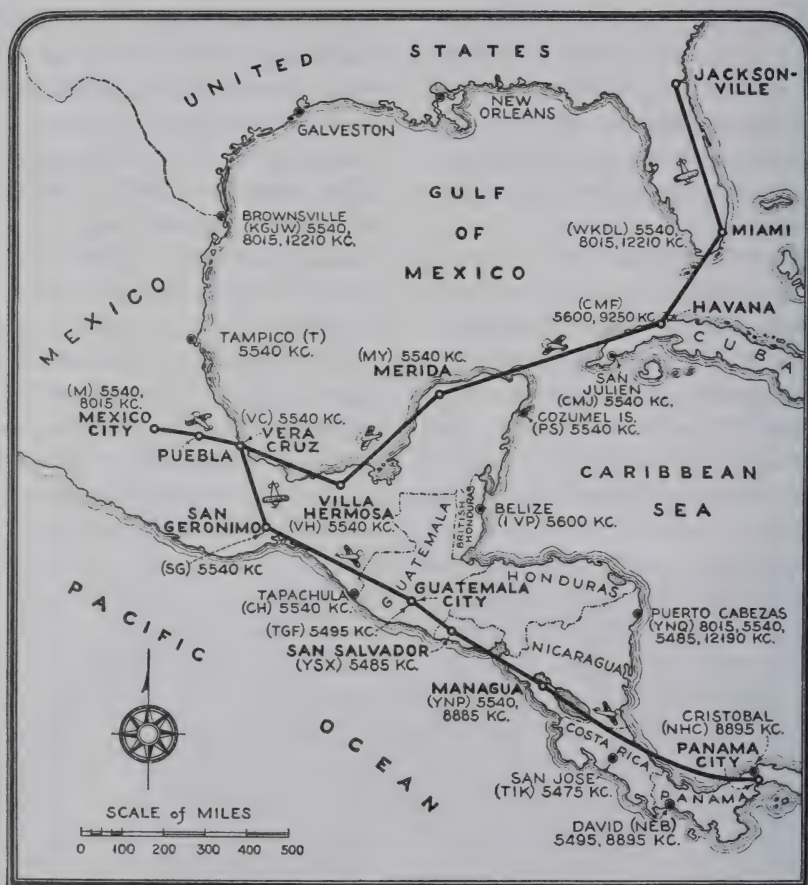


Fig. 21. The first leg of the *Pilot Radio GWF*. Pan American Airways radio stations and their primary frequencies are shown. (*Radio News*, Jan. 1931, p. 587)

found from Pan Am station weather reports, would clear as they approached their destination, Vera Cruz. Once a great city, it had more recently been called “a crumbling, dying town,”⁶⁸ described by Bouck as “the hottest and dustiest seaport in the world.”⁶⁹ The airfield serving the city was located 20 miles away at Tejeria.

From there they began their mission to escort a Mexican seaplane, the

Mayab, which was carrying the remains of Colonel Pablo Sidar to an elaborate public funeral ceremony in Mexico City, where they would be interred in a place of honor next to fellow Good Will flyer Emilio Carranza. Sidar, posthumously promoted to Major General, was the intrepid, 27-year-old pilot who had completed a 26,000 mile GWF just months before, and had died attempting yet another GWF, this one

a record-seeking, nonstop, 5,000-mile flight from Mexico City to Buenos Aires. After eight hours he and his copilot ran into a storm off the Atlantic coast of Costa Rica and their land plane was forced down into the sea just fifty yards from shore.⁷⁰ The *Pilot Radio*, having just started its own GWF, would represent the United States in the aerial funeral cortege and was to keep Mexico City informed of the procession's progress by radio. Although the suggestion probably came from the State Department, escorting the *Mayab* was also a personal duty for the *Pilot Radio*'s crew—both Yancey and Burgin had been friends of Sidar, a fellow member of "The Quiet Birdmen," a group of aviators whose gatherings were famous for being *anything* but quiet.⁷¹

Escort duty wasn't easy. The next morning, May 21, the *Pilot Radio*, the *Mayab*, and three Mexican Army planes took off into the clouds and for 2½ hours tried to climb above them in order to locate the pass at Orizaba. They ascended to 15,000 feet but were still at times blinded by clouds and risked colliding with each other or the mountains. Eventually, station VC informed them that the *Mayab* had given up and returned to Tejeria. They returned there with two other planes; the third had made it through the fog and on to Puebla, their intermediate destination, after bumping the railroad tracks in the pass twice in the process. The following day, weather conditions were ideal. They made it easily over the mountains and down into Puebla, where a solemn funeral procession ensued. May

23 found the cortege proceeding on to Balbuena Field in Mexico City, with Bouck sending reports to the Mexican Secretary of War every fifteen minutes while still keeping in touch with the *New York Times*. They arrived at the city "nestled in a plateau 7,000 feet above the sea, surrounded more often than not in clouds and storms," at 11:30 AM, where a crowd of soldiers and thousands of civilians lined the streets. The funeral urns were placed in Colonel Sidar's old plane, *Ejército Mexicano*. Its wings having been removed, it was drawn through the streets as his hearse.

Bouck, Burgin, and Yancey were decorated by the Mexican government for their participation in the funeral (see Fig. 22). The *Pilot Radio* remained in Mexico City for five days, during which the plane's engine was checked, and Bouck experimented with communications via an emergency antenna. Demonstrating the radio's capabilities to members of the Mexican Army, he had a hard time convincing them that the set was not for sale. During the layover, most of their flying was done at the Regis Hotel Bar.

There they experienced an incident best described in Bouck's own words: "At another table were the son of the lately assassinated President Obregon, a girl, and our old friend Colonel Leon. In struts a Mexican appareled according to the best Hollywood tradition: leather trousers and jacket, spangles, lace and filigree, a gold and silver holster, cartridge belt studded like the harness of a pet pony, and all of this glittering caballero topped with a sombrero



Fig. 22. The *Pilot Radio* crew is decorated by the Mexican government for their participation in the funeral of Colonel Pablo Sidar. Left to right: William Olenberger, Colonel Leon, Zeh Bouck, Señor Valdez, Lewis Yancey, Emile Burgin, and Eddie Walsh. (*Radio News*, Jan. 1931, p. 588)

of indescribable gorgeousness.” After quaffing some drinks at the bar, he “cast his eyes belligerently over the cantina. The Mexican started as he saw young Obregon, stumbled over to the table and began to pull an ornately engraved revolver from his holster. He was watching Obregon’s face, not his hand, and his befogged eyes failed to read the fact that Obregon had drawn an automatic from a shoulder strap, and had it pressed against his lace-covered belly. In a flash, Leon reached across the table, forced the revolver back into the holster and the Mexican from the table.” As the would-be assassin was being booted from the premises, Bouck was told that “Leon was a fool. He should not have interfered. Obregon would

have killed him in another moment.” “Things are not as they used to be,” he was informed in a rueful voice. “In the past year there have been only five—no, not even five, only four—people shot here in this bar.”⁷²

On Thursday, May 29, after a difficult takeoff in the thin air, as the *Pilot Radio* circled to gain the altitude needed to cross the mountain pass the oil pressure suddenly dropped, forcing a return to Balbuena Field. Wright mechanic Eddie Walsh was summoned. He picked a bit of dirt out of a check valve and they were on their way. Fighting wind and rain, they made their way over the pass. Pan Am station VC informed them that the weather would clear further ahead. They felt their way through the

narrow valleys under a fifty-foot cloud ceiling. Breaking clouds revealed the sea ahead and the city of Vera Cruz, from where they would resume their southward GWF, starting with refueling in San Jerónimo, Mexico. Even this wasn't easy: they were forced to do a "go around," aborting their first landing attempt when they spotted someone on the field.

Approaching their next port of call, Guatemala City, perched among 8,000-foot mountains and accessible only through a narrow pass, could be difficult, but the *Pilot Radio* was able to follow behind the Pan Am flight of a Ford trimotor plane manned by a pilot who knew the route. As Pan Am flights carried radio operators, the two "ships" maintained communications, and the Pan Am flight called out points of interest to the *Pilot Radio* like a tour guide. Taking off with a full load of gas from a wet field in the thin air next morning, they cleared an ancient viaduct by just inches, but the pass was closed off by clouds, causing a return to the airport to await better weather. This they got on the following day on June 1. Hop-ping off in the opposite direction due to a change in the wind, Burgin had to dip one wing to avoid hitting some tree branches, and finally, once clear, pushed on over the mountains.

Curiously, this wouldn't be the last time this short runway, high elevation, and a heavy load of fuel for a hop southward would be critical factors in a GWF. Some eight years later, famed French adventurer, inventor, Aéro-postale airmail pilot, and author of *The*

Little Prince, Antoine de Saint-Exupéry, along with his mechanic, were nearly killed when they crashed attempting to hop off from this same airfield on a French Aviation Ministry GWF. Most likely, their plane had been accidentally overloaded with fuel due to confusion about the use of U.S. versus Imperial gallons.⁷³ And notably, by that time Saint-Exupéry, with whom the *Pilot Radio* flyers may have crossed paths in Buenos Aires, had been so impressed with the U.S. system of radio navigation (which had not yet been implemented in his native France) that he considered carrying maps optional on U.S. flights!⁷⁴

From high above Guatemala, Bouck radioed back a weather report for the benefit of a plane taking off at Vera Cruz. He also managed to QSO an amateur station in Hartford, Connecticut, some 2,000 miles away.⁷⁵ Could this have been the ARRL station, W1AW? Short of a QSL card turning up, we will probably never know. The *Pilot Radio* passed over Corinto on the Pacific Coast of Nicaragua, a port Yancey had visited twenty years before when he was in the Navy. After a total of seven hours in the air they landed in Managua, Nicaragua (see Fig. 23), "a section of Central America just slightly hotter than hell." The country was "hot" in another way too. U.S. Marines were there fighting the forces of guerilla leader Augusto Sandino. After landing at the Marine Corps field, Bouck was able to use USMC radio station NN1NIC to work W2QU in New Rochelle, New York. Less than a year later NN1NIC would



Fig. 23. The GWF at the U.S. Marine Corps field in Managua, Nicaragua, June 1, 1930. Several thousand U.S. Marines and six Army planes were operating in Nicaragua at the time. (*Radio News*, Jan. 1931, p. 642)

be put to better use as one of the few links to the outside world after an earthquake and fire leveled Managua, killing thousands.⁷⁶

The next morning, they again faced an unavoidable hazard—taking off from a short runway in an overweight plane carrying a lot of gas. “With the tail slapped up against the western fence, Eddie gave her the gun, and the ‘Pilot Radio’ rolled lumberously toward the center of the field. Finally, half way down, he got the tail up, and we gathered speed with the other fence becoming more and more definitely in the way. Desperately Eddie tried to bump her off, while I [Bouck] stuffed a brief-case between me and the gas tank. She’d hold the air for a second, then settle. Eddie pulled the wheel back to clear the prop—a sudden jolt and good-bye fence.” They managed to get

airborne with no damage to the plane after taking out the fence, but it was a close call, and one they would remember next time.

The flight to Panama was about 500 miles “as the crow flies,” but more than 700 miles as the *Pilot Radio* would fly, since they preferred to hug the coast rather than fly over open water where an emergency landing would likely be fatal. About 100 miles from their destination, they had to fly around a tropical rainstorm—it was the rainy season, after all. They landed in France Field, Panama, around 3:30 p.m. After landing, they noticed a problem with a magneto, so this was repaired and the engine was given a thorough going-over, which included alterations to adapt the oil cooling system for tropical conditions. All of this was done by Pan Am mechanics at the field, and it would

take a few days. Bouck had previously scheduled a transmission to the *New York Times* station WHD, assuming he would transmit from the air, but now the plane was down on the field being serviced. He decided to try it anyway to keep to the schedule and provide a demonstration to U.S. Army and Pan Am personnel. The latter were probably curious as to how the *Pilot Radio* setup compared with the Leuteritz-designed radios that were standard for Pan Am planes (see Fig. 24).

Both systems were fairly similar. Both receivers used a screen-grid tuned RF stage ahead of a regenerative detector and two stages of audio amplification. Both transmitters were

MOPA with plug-in coils, but the Pan Am aircraft transmitter put out fewer watts (12 vs. 60–70).⁷⁷ Leuteritz had previously experimented with higher-power (100–200 watt) transmitters but found them heavier and more prone to break down. Pan Am's setup was probably lighter than the *Pilot Radio*'s, but it's hard to tell since the weight they reported (42 lbs.) did not include that of the batteries, which typically weighed more than the sets. For his ground-based demonstration, Bouck probably tuned around 7,300 kHz (41 meters), strung an antenna wire from the plane to a step ladder (or a car or a truck; accounts varied) on the field, "and made contact with New York without

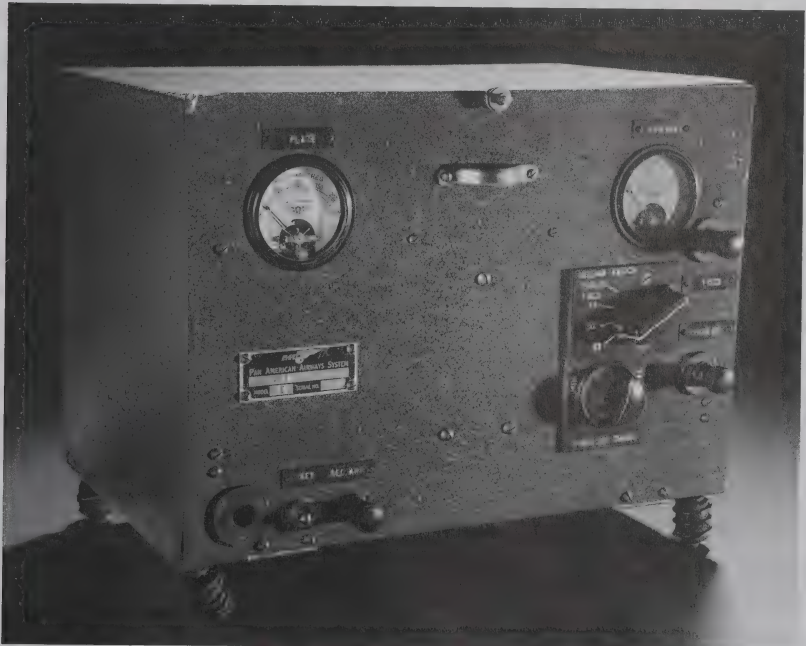


Fig. 24. Leuteritz-designed Pan Am radio transmitter used by Charles Lindbergh from 1931–1933. A similar unit was in use aboard Pan Am flights in 1930 at the time of the *Pilot Radio* GWF. (Smithsonian National Air & Space Museum, NASM 2011-00584)

difficulty, a distance of some twenty-five hundred miles, in daylight!" It was said to establish a new record for emergency plane communication, demonstrating a capability that would come in handy if they were ever forced down.

For four days, the flyers spent much of their ground time in Colon, Panama, and a city within that city—one that was technically part of the United States—Cristobal, Canal Zone. The time being Prohibition, the difference between the two mostly had to do with alcohol. No depression was evident in "wet" Panamanian Colon, where Bouck documented a teeming cabaret night-life complete with ladies who would introduce themselves and encourage patrons to buy them expensive drinks that turned out to be non-alcoholic. On the fifth day of their layover in this environment, with the plane once again flight-worthy, came a demonstration of long distance spouse-to-husband communication for Yancey. As Mrs. Yancey sat at the *New York Times* office, she dictated short messages to the *Times* radio operator, who keyed them in and sent them over the airwaves to the plane circling 4,000 feet above Panama. Bouck relayed the messages to Yancey, who dictated replies to Bouck, who keyed them back. The text of these communications was not published.⁷⁸

The next leg of their journey would bring them to the South American continent. It began on June 8 and required some special considerations. It would involve a 1,200-mile flight that included 800 miles over water. Even during the land portion of the trip, there were no

known landing fields they could use in an emergency. The France Field airstrip where they hopped off was short and soggy. This being the rainy season, it had rained every day. Remembering their near-disastrous hop-off at Managua, and needing to fill their gas tanks to the brim this time, Yancey decided that "there was nothing for it then but to lighten the plane up as much as possible . . . The local representative of Pan American Grace Airways very kindly offered to send anything down to us that we left behind."⁷⁹ This was to include the radio and its unhappy operator. "Over Bouck's protest I piled him out and lightened the ship by another 160 pounds." Reading between the lines of Bouck's account of this, entitled "Deserted in Panama," and reflecting on how it must have felt to be treated like overweight baggage to be sent ahead later, one might imagine a bit of tension between Yancey and Bouck; much more would come out on this later.

So the formerly aerial but now grounded radioman watched as the plane hopped off, noting that, the engine cowlings and exhaust rings having been removed to improve cooling, the engine shot sharp blue exhaust flames into the morning twilight. The takeoff went smoothly and was described by Bouck who, as usual, adopted the "royal 'we'"; "We saw there was plenty of climb in the old bus and realized that another hundred and fifty pounds or so would have made a negligible difference. However, here we were in Panama, for a whole day, with nothing on our mind but sandflies."⁸⁰

Of the now radio-less (but at least not pilot-less) *Pilot Radio*, nothing would be heard for a while. "Plane of L. A. Yancey Long Overdue on South American Good Will Tour,"⁸¹ proclaimed the papers the next day.

To be continued . . .

Correction

Part 1 of this series incorrectly stated that William Alexander was the holder of FAI international pilot license #1. This was found in several sources, but a check of original records shows that, in fact, his FAI license number was 447. The honor of having license number 1 went to Glenn Curtiss. The author thanks Hayden Hamilton (American Aviation Historical Society) for making the original records available and pointing this out.

Endnotes

1. R. M. Rydzewski, "Zeh Bouck, Radio Adventurer. Part I: The Pilot Radio Flight to Bermuda," *Antique Wireless Association Review*, Vol. 30, 2017, p. 31.
2. H. A. Bruno, W. S. Dutton, "The Ocean-Hopping Bug," *Liberty*, May 6, 1933, p. 32.
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About the Author

Bob Rydzewski, KJ6SBR, is a native of Chicago, Illinois, where his parents had worked at various times for Teletype Corporation, Belmont Radio, and Zenith. One of his earliest memories is of looking up to the eerie green magic eye of a 1930s Zenith console. His interest in electronics as a hobby began about the time he assembled an Eico 460 oscilloscope in a high school physics lab. Around 2000 he developed an interest in collecting and restoring old radios. Inspired by Alan Douglas's *Radio Manufacturers of the 1920's*, he began searching out the fascinating and often forgotten stories behind the early days of wireless.

Bob received an MS in chemistry from DePaul University and went on to a 25-year career in pharmaceutical

and biotech R&D, eventually penning a textbook on drug discovery. His writing abilities came the fore in his current career as a professionally accredited medical writer, helping doctors present clinical trial results through journal articles and congress presentations. Bob and his better half live in the San Francisco Bay Area where he is a proud member of the California Historical Radio Society.



Bob Rydzewski

Did Mahlon Loomis Really Invent Radio?

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Some historians credit Mahlon Loomis for being the first to demonstrate the transmission of intelligible messages by electromagnetic radiation using two kites as “antennas” that were separated by a distance of approximately 20 miles in the Blue Ridge Mountains of Virginia in 1866. Loomis documented his approach in U.S. patent No. 129,971 dated July 30, 1872, which was supplemented by entries in his notebooks, an address to the Franklin Institute, and several other contemporaneous documents including those that accompanied his patent filing. His technique is unique among all methods of wireless telegraphy because he claims to have successfully extracted electricity from the atmosphere to power his system, as opposed to using batteries or rotating machinery as the source of power for the electrical disturbances he generated. Most mainstream scientists are skeptical of Loomis’s claims because of the difficulty of obtaining the necessary energy and power from the atmosphere for communicating intelligence to such a distance, and also because he used a galvanometer as a detector without benefit of a nonlinear detector, such as a coherer or magnetic detector. If Loomis actually did send and receive messages with electromagnetic signals, then he deserves credit for being the first to demonstrate communication by radio, even though he did not realize the method by which he was communicating. If not, then he will remain a footnote in the history of wireless communication, remembered as the first one who tried but failed to transmit messages by extracting the necessary energy or power from the atmosphere.

The objective of this paper is to determine whether or not Mahlon Loomis could have transmitted intelligence by electromagnetic radiation, which is and has been the definition of radio since the early 1900s.¹ Loomis claimed that he first demonstrated transmitting and receiving signals in the Blue Ridge Mountains of Virginia in 1866 using two kites separated by a distance of approximately 20 miles with copper wires connected to conducting mesh patches attached to each kite, although

he never actually claimed that he sent intelligible messages in his demonstration in the Blue Ridge Mountains. He also never claimed that he used electromagnetic radiation as the means by which he transmitted signals. However, to this very day there are various sign markers in different parts of the country where Loomis lived, experimented, and was buried, which proclaim he successfully transmitted signals between two Blue Ridge Mountain peaks (see Fig 1).²

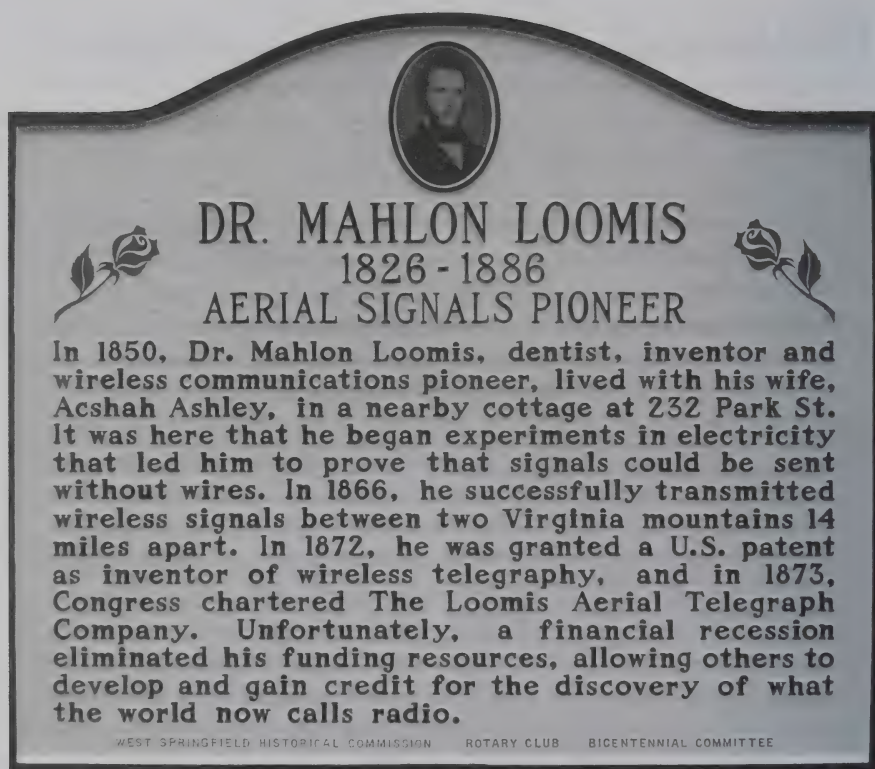


Fig. 1. This sign appearing in West Springfield, MA, proclaims that Mahlon Loomis, an aerial wireless pioneer, proved that signals could be sent and received without wires between two mountains in Virginia in 1866. (Waymarking Images)

In all fairness to Loomis, the existence of electromagnetic radiation and the means for generating it was not discovered until 1887, fifteen years after he received a patent for his approach to what he called “aerial” telegraphy. Because an inventor does not have to understand how his invention works, it is not necessary that Loomis’s explanation of how his invention worked was correct—but it is necessary that the invention he described is capable of producing the results he claimed. Consequently, the specific objective of this paper is to

determine if the physical configuration Loomis described in his patent, supplemented by supporting documents, was capable of transmitting and receiving intelligence using electromagnetic radiation—even if unwittingly.

By all accounts, Mahlon Loomis, who is shown in Fig. 2, was an educated man and a serious inventor who pursued an approach for wireless communication of intelligence by extracting the necessary energy from atmospheric electricity rather than using man-made sources of energy such as a bank of batteries. He

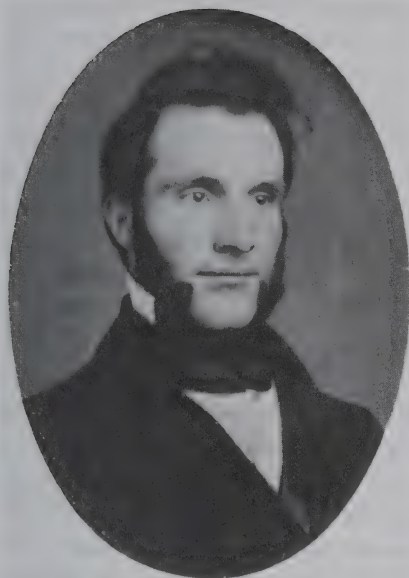


Fig. 2. Portrait of Mahlon Loomis. (Library of Congress, Manuscript Division)

was born on July 22, 1826, in Oppenheim, New York, to the family of Professor Nathan and Waitie Loomis, and while little is known about his early life, he was surrounded by educated minds, and he became a dentist as an adult. Wireless telegraphy was his avocation, one he relentlessly pursued.

Loomis's method of wireless telegraphy is documented in his U.S. patent No. 129,971 dated July 30, 1872, his contemporaneous writings, his diaries, and in many newspaper accounts. Most mainstream scientists are skeptical of Loomis's claims for two different reasons. First, he used an ordinary dc galvanometer—as opposed to some type of nonlinear method or device that was used to detect signals in virtually all receivers that used electromagnetic waves—as a

means of communicating intelligence to the far field of the radiating antenna.³ Second, he claimed he obtained the necessary energy and power from electricity in the atmosphere—as opposed to batteries or rotating machinery used to power virtually all transmitters of electromagnetic waves.

Paper Organization

The analyses are divided into four distinct parts, the results of which are integrated at the end in a coherent way to summarize and draw conclusions. Part I is an analysis of claims made by and on behalf of Mahlon Loomis for his method of wireless telegraphy. Two documents were used for virtually all of the descriptive material cited in Part I. The first is a comprehensive document written by Thomas Appleby entitled *Mahlon Loomis, Inventor of Radio*,⁴ in which many important but obscure documents written by Loomis are reproduced. Appleby obtained these documents from the Manuscript Division of the Library of Congress.⁵ From the title of his book, it is clear that Appleby was convinced Loomis was able to communicate to long distances using radio waves. Appleby claimed that Loomis was able to communicate to distances of 20 miles using two kites tethered by string along with a conducting wire of 600 feet in length. The second document is an article appearing in the December 1922 issue of *Radio News*,⁶ which contains a rather complete and concise description of his work and a few interesting images attributed to Loomis that do not appear in the Appleby document.

Part II consists of analyses to determine 1) the upper bound to the energy per pulse and power that a Loomis kite could have extracted from the atmosphere and radiated by a spark discharge, and 2) the strength of a signal that could be collected by a receive antenna located at a distance of 20 miles from the transmit antenna. To the author's knowledge, no historian or scientist has ever documented estimates of these important quantities. As a prelude to this analysis, the accepted model of the electrical energy available in the earth-ionosphere cavity is summarized. This model is used to determine the maximum voltage, charge, and energy that the Loomis antenna could have accumulated from the natural electricity in the atmosphere prior to each discharge.

Part III provides experimental data on the maximum voltage and the

charging time required to build up sufficient charge to produce each subsequent discharge. The charging time is critical because the charging rate determines not only the power radiated, but also the transmitted word rate. Typical word rates of interest for telegraphy at the time were ten to twenty words per minute. Word rates excessively longer than that could make communicating intelligence impractical or impossible.

Part IV documents how galvanometers respond to short pulses and provides experimental data to quantify the sensitivity of galvanometers believed to be similar to the type Loomis used. It will become clear why even the most sensitive galvanometers of the day, which were developed and used for marine cable telegraphy, would not work for aerial telegraphy using electromagnetic waves.

PART I. CLAIMS BY AND ON BEHALF OF MAHLON LOOMIS

Mahlon Loomis Patent U.S. 129,971: Improvement in Telegraphing

An appropriate place to begin an explanation of Mahlon Loomis's approach to wireless telegraphy is his U.S. patent 129,971 dated July 30, 1872. The patent begins with a statement that the single wire and batteries normally used in wired telegraphy are dispensed with and the ground constitutes one-half of the circuit:

"As in dispensing with the double wire, (which was first used in telegraphing,)

and making use of but one, substituting the earth instead of a wire to form one-half the circuit, so I now dispense with both wires, using the earth as one-half the circuit and the continuous electrical element far above the earth's surface for the other part of the circuit. I also dispense with all artificial batteries, but use the free electricity of the atmosphere, co-operating with that of the earth, to supply the electrical dynamic force or current for telegraphing and for other useful purposes, such as light, heat, and motive power."

In the method of communication by electromagnetic radiation involving monopole and dipole antennas, the only means of conveying information is through propagating electromagnetic waves in space—not by means of ground currents flowing from the transmitter to the receiver. For monopole antennas, ground currents do, in fact, flow in the earth in the near-field region of the antenna (within a few wavelengths)—but only to enhance the electromagnetic radiation, not to transmit information through the earth to the receiver. Communication by electromagnetic radiation is a one-way trip with no return currents through the ground or air involved in the transfer of intelligence. Thus, Loomis's description is not one of using electromagnetic radiation to communicate intelligence. Loomis's description of a return current flowing through the earth is actually a classic example of a wireless method known as quasi-static electric-field induction, the method described and documented later by Thomas Edison in his quintessential patent for wireless communication by electrostatic induction (U.S. 465,971) filed on May 23, 1885, a few years before Hertz discovered electromagnetic radiation.

Loomis moves on rather quickly to the one and only claim made in the patent, which is contained in a single and almost incomprehensible sentence:

"I do not claim any new key-board nor any new alphabet or signals; I do not claim any new register or recording instrument; but "What I claim as my invention or discovery, and desire

to secure by Letters Patent, is—The utilization of natural electricity from elevated points by connecting the opposite polarity of the celestial and terrestrial bodies of electricity at different points by suitable conductors, and, for telegraphic purposes, relying upon the disturbance produced in the two electro-opposite bodies (of the earth and atmosphere) by an interruption of the continuity of one of the conductors from the electrical body being indicated upon its opposite or corresponding terminus, and thus producing a circuit or communication between the two without an artificial battery or the further use of wires or cables to connect the co-operating stations."

Note that Loomis does not specify the type of recording instrument, does not describe what constitutes a "celestial body" or a "terrestrial body," and does not say how conductors are to be attached between the two. If it were not for other documents describing his concept in more detail, it is unlikely that anyone would have taken notice of this patent. A sketch of this configuration drawn by Loomis that accompanied his patent submission is reproduced in Fig. 3.⁷ It is only in these supplementary documents that he explains the celestial bodies are two conducting copper gauze patches with dimensions of 15 by 15 inches (40 by 40 cm) that are attached to two separate kites tethered by a string, each kite with a conducting wire 600 feet in length that is attached to a patch at one end and leads to the ground at the other end. The terrestrial bodies are coils of wires grounded



Fig. 3. This drawing that appeared in the patent papers of Mahlon Loomis clearly shows one experimenter (to the left) touching a wire leading from the transmitting kite to a terminal on a galvanometer, while a second experimenter (to the right) is observing the response. (*Radio News*, Nov. 1922, p. 836)

in separate pools of water located miles apart at sending and receiving stations. The sending station consists of a wire from one kite that is periodically touched to ground through one terminal of the galvanometer—the other terminal of the galvanometer being grounded in a pool of water. The receiving station consists of a galvanometer that has one terminal connected to the second kite wire for receiving the signals and the other terminal connected to a ground wire lying in the second pool of water, which constitutes the return path of the signal to the sender.

Loomis's Knowledge of Atmospheric Activity

Loomis, a very educated man, was aware that atmospheric electricity was abundant, and he believed it was more abundant at higher altitudes where “clouds and air currents were left behind.”

According to Appleby, Loomis attended a series of lectures in 1853–54 given by Professor Joseph Lovering at the Lowell Institute in Boston. He may also have read of the many important contributions to the study of atmospheric electricity made by Lord Kelvin (William Thomson) during a brief but productive period from 1859–1861.⁸ Most of Kelvin's work on atmospheric electricity was published under his William Thomson name between 1855 and 1865, a period coinciding with the period that Loomis developed his ideas on wireless telegraphy using atmospheric electricity. Kelvin's work is summarized in an excellent article entitled “Lord Kelvin's Atmospheric Electricity Measurements,”⁹ which puts Kelvin's work in context and provides many references under the name of Thompson from 1855 to 1865.

Loomis had some knowledge of atmospheric electricity, as indicated by

the following excerpt taken from his lecture to the Franklin Institute in 1881:

"It is a well established scientific fact, that free electricity abounds in our atmosphere, that scarcely any traces of it are found less than four feet from the surface of the earth, but on attaining greater height, it becomes more apparent, and the greater the altitude the more this element abounds; so that, in reaching an elevation above the clouds it becomes so prevalent as to form a continuous and distinct element, in which our globe with its surrounding atmosphere lies and floats. That is a demonstrated fact.

"It is also a well established fact in all electrical phenomena, that certain electrical conditions, called 'positive' and 'negative,' must exist, in order to form a 'circuit' or current with the electrical fluid. And these conditions we find most admirably arranged in the great electrical battery of nature. The earth, like the outside of a Leyden jar, or the copper plate of a galvanic battery, is always highly charged with negative electricity. The atmosphere, like the inside of a Leyden jar, or the zinc plate of a galvanic battery, is always charged with positive electricity, and the intervening air like the glass, of the Leyden jar, or separated poles of the galvanic battery, is a perfect non-conductor, thus forming and constituting the most complete and colossal electric battery, that ever gave an electric spark, but standing all unused and as much superior to all artificial batteries—just as much

superior to all artificial batteries combined, as the sun is superior to our tallow candles."¹⁰

While Loomis knew there was abundant electrical energy in the atmosphere, he did not have the correct picture of the electricity in the earth-ionosphere cavity, as it is now understood, which is addressed in a later section. He believed there was a current of electricity that moved horizontally at these higher altitudes that could be reached by a pair of kites launched from two widely spaced mountaintops. In papers submitted with his patent application, he illustrated this concept with a sketch dated 1864, reproduced here as Fig. 4,¹¹ where he represented electrical charge at high altitude flowing horizontally in layers, as indicated by the dashed lines. He reasoned that he could disturb the electrical equilibrium of this strata by making an electrical connection to this current with a wire connected to a conducting copper patch held aloft on a kite, and attaching the other end of the wire to ground. The disturbance, thus created, would be propagated to a second conducting surface held aloft by a second kite and detected by a galvanometer connected between the wire from the second kite and ground. The circuit would be completed by conduction current through the earth, as indicated by the dashed lines below the surface of the earth. It is now known that there is a flow of current in the atmosphere, but that the flow is perpendicular to the earth's surface—not parallel to it—and its magnitude is very small.

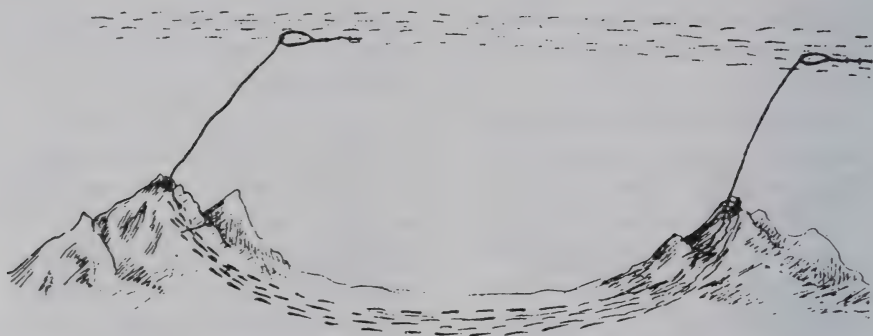


Fig. 4. Loomis's concept was to disturb the electrical horizontal strata that he believed existed at higher altitudes by grounding a conducting electrode attached to one kite, and the resulting disturbance would be felt by another electrode on a second kite, flying at exactly the same altitude, whose conducting wire was attached to a galvanometer on the ground. The current flowing from the second kite to ground through the galvanometer would return through the earth (as indicated by the dashed lines) to the grounded wire connected to the first kite, thus closing the current loop. (Library of Congress)

Loomis's Experiment in the Blue Ridge Mountains

Thomas Appleby's book has a description of Mahlon Loomis's experiment taken from Loomis's notes that reside in the Loomis Collection at the Library of Congress.¹² The following excerpt is taken from Appleby's book, where he quoted from the notes Dr. Loomis made of his first demonstration experiment in the Blue Ridge Mountains in 1866. Loomis wrote that his description "is related precisely as it occurred." Loomis begins this description as follows:

"From two peaks of the Blue Ridge in Virginia which are only about two thousand feet above tide water, two kites were let up—one from each summit—eighteen or twenty miles apart.¹³ These kites had each a small piece of fine copper wire gauze about fifteen inches square attached to their under

side and connected also with the wire six hundred feet in length which held the kites when they were up. The day was clear and cool in the month of October with breeze enough to hold the kites firmly at anchor when they were flown. Good connection was made with the ground by laying in a wet place a coil of wire one end of which was secured to the binding post of a galvanometer. The equipments and apparatus at both stations were exactly alike. The time pieces of both parties having been set alike, it was arranged that at precisely such an hour and minute the galvanometer at one station should be attached, or be in circuit with the ground and kite wires. At the opposite station the ground wire being already fast to the galvanometer, three separate and deliberate half-minute connections were made with the kite wire and the instrument. This

deflected, or moved the needle at the other station with the same vigor and precision as if it had been attached to an ordinary battery. After a lapse of five minutes, as previously arranged, the same performance was repeated with the same results until the third time.”¹⁴

While Loomis’s notes continue, the most interesting part of his description of the demonstration is contained in the last three sentences above, which are the most telling of all. He states that at one end (the receiver), the galvanometer was attached in a circuit with a ground wire and a kite wire. At the other end (the transmitter), he placed a wire from one side of the galvanometer to ground, and then “three separate and deliberate half-minute connections were made with the kite wire and the instrument [the terminal of the galvanometer].” So the galvanometer was in the circuit of both the transmitter and receiver. Loomis’s description of having the galvanometer in the transmitter circuit is consistent with his drawing reproduced in Fig. 3, which clearly shows an experimenter on the left touching the lead from the antenna to one of the terminals of the galvanometer.

Note that “deliberate half-minute connections [that] were made with the kite wire and the instrument [galvanometer terminal]” would not produce successive sparks—just one spark at the initial contact.¹⁵ More to the point, “half-minute connections” would not have “deflected, or moved the needle at the other station with the same vigor and precision as if it had been attached to an ordinary battery.” The galvanometer

needle at the receiver would have jerked momentarily as the contact was made at the transmitter, and then it would have returned to zero for most of the 30-second period that the wire was held against the galvanometer—quite *unlike* the response produced by connecting a galvanometer to a battery. If a galvanometer had been connected to a battery, it would have produced a steady deflection, quite unlike the response of any type of wireless method, whether it be by electromagnetic radiation or quasi-static electric-field induction. Both forms of wireless telegraphy require a changing electric or magnetic field to couple signals into distant circuits.

Note also that immediately after the first contact of the wire to the galvanometer at the transmitter, the configurations at the transmitter and receiver are identical. Both kite wires are connected to their respective galvanometers for the 30-second period Loomis describes, and by symmetry, the reading on the two would have been essentially the same. If one galvanometer had a steady deflection—the other galvanometer would also have had a steady deflection. In essence, the transmitting station is indistinguishable from the receiving station during this period—and the two could not communicate with each other during the 30 seconds. The only possible explanation for a steady deflection is that Loomis was actually measuring the steady-state drain of current flowing from atmospheric electricity onto the antenna and then to ground through the galvanometer. If so, this would not constitute communication from a station 20 miles distant.

Finally, note that Loomis repeated three “separate and deliberate half-minute connections....after a lapse of five minutes.” The fact that he waited five minutes between each “connection” to the galvanometer at the transmitter is important in determining the actual voltage that his antenna reached before each connection (i.e., discharge). This issue is addressed in a later section describing the time evolution of the voltage of the Loomis antenna.

One can only believe that Loomis described what he *thought* would have happened had the current flowed through the atmosphere directly from the transmitter to the receiver—as if the atmosphere acted like a conducting wire. The air at all altitudes of interest has such a high resistance that it would have been impossible to form a conducting path through the atmosphere between two Loomis antennas.

This description also raises a question as to whether Loomis ever created or observed a potential difference sufficient to cause a discharge by touching the terminal of his galvanometer. Loomis never made any statement that he observed or created a spark discharge. If he did produce a spark, there is an issue about whether a sensitive galvanometer could withstand a large pulse of electricity at the transmitter without suffering severe damage to the very delicate wires in the coil or damage to the insulation between turns on the wires. Note that lightning protectors were used on submarine cables of the day to prevent damage to sensitive galvanometers by pulses exceeding several hundreds of volts.

Appleby's Analysis of Loomis's Concept as an Electromagnetic Wave Radiator

As far as I am aware, Thomas Appleby was the first to seriously advocate for Loomis as the inventor of radio—that is to say, for communicating intelligence by electromagnetic radiation. He defined a circuit configuration for a transmitter, consistent with Loomis's patent description, that could radiate electromagnetic energy without the need for ground currents to flow in the earth between transmitter to receiver (see Fig. 5). In the text accompanying his figure, Appleby states: “When the overhead [static-charged] cloud charged the aerial A and top loading capacitor C, sparks S would jump across the contacts as key K was closed and oscillations would be set up in the entire circuit between capacity C and earth connection E.” Appleby's drawing is somewhat misleading because it seems to indicate that atmospheric electricity is attracted by the small 40×40 centimeter conducting patch on the kite, when, in fact, charge is attracted by the entire length of the 183-meter antenna wire as well. It will be shown later that the surface area of the kite wire is approximately twice as large as the surface area of the fine copper gauze on the kite itself, and that the capacity of the antenna wire to ground is much larger than the patch located almost 600 feet from the ground.

Appleby provided a rather superficial analysis to support his contention. He assumed the antenna (with conducting patch) would charge up to a high but unspecified potential by “a static-charged cloud” in the air that would be sufficient

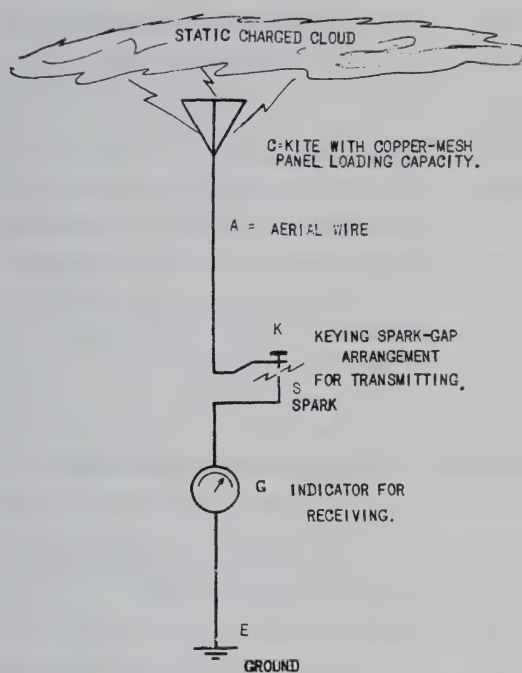


Fig. 5. Thomas Appleby was the first to seriously advocate for Loomis as the inventor of radio by defining this circuit configuration, consistent with Loomis's patent description, that he believed could radiate and receive electromagnetic energy without the need for ground currents to flow in the earth from transmitter to receiver. (Appleby, *Mahlon Loomis*, p. 21)

to produce a discharge across the telegraph key. However, he provided no analysis to indicate what potential that might be. Appleby does cite a newspaper article of one Mr. Swope who flew a kite to a height of 1600 feet (488 meters) with a metal wire and claimed to observe a spark 3 inches (7.6 cm) in length.¹⁶ It will be shown later that the potential gradient in the vicinity of the earth's surface is approximately 100 volts per meter, so that a kite at a height of 488 meters could have obtained a potential no greater than $488 \text{ m} \times 100 \text{ V/m}$, or about 50 kV. Since

the breakdown threshold of air in the vicinity of the earth's surface is 3 MV/m or 30 kV/cm, a 50-kV pulse could not have produced a spark length much greater than 1.7 cm, or 0.67 in. Hence, this newspaper report of a three inch spark is not credible.

The only analysis that Appleby actually performed was an estimate of the resonant frequency of a monopole antenna with a height of 600 feet excited by a spark discharge. He assumed the kite wire had a diameter of 0.04 inches (1 mm), although he never used that parameter in his analysis. He calculated that a grounded vertical wire 600 feet in length (183 meters) had a resonant frequency of 0.389 MHz or a wavelength of 700 meters.¹⁷ He did not account for a ground plane with finite resistance or the

fact that the galvanometer, with its considerable inductance and resistance, was in the transmitter circuit. The resonant wavelength he calculated is essentially the same as the resonant wavelength and frequency of an ideal monopole antenna of length of 183 meters over a perfectly conducting ground plane connected to a matched load, which is four times the antenna height, namely 732 meters, corresponding to a resonant frequency of approximately 0.4 MHz.

Most serious historians who have considered Loomis's approach, Thomas

Appleby included, have noted that he used only a galvanometer without the usual non-linear device required to detect the high-frequency signal such as a coherer, crystal detector, magnetic detector, vacuum tube, etc. Thomas Appleby and others have suggested that Loomis may have configured his galvanometer in some unspecified manner to take advantage of the non-linear magnetic hysteresis phenomenon (irreversibility of

the magnetization and demagnetization process in ferromagnetic materials such as iron)—the same basic principle used in the Marconi magnetic detector. Loomis never mentioned this possibility, and no one has ever explained or demonstrated how Loomis might have accomplished this in conjunction with his galvanometer. Consequently, this suggestion remains in the realm of sheer speculation and cannot be taken seriously.

PART II: LOOMIS ANTENNA TRANSMISSION AND RECEPTION

The objective of Part II is to determine the upper bound to: 1) the voltage of the Loomis kite wire and conducting mesh, 2) the energy that can be extracted by a Loomis kite from the electrical environment in the earth's atmosphere, 3) the energy transmitted by a Loomis antenna, 4) the energy received by a second Loomis antenna, and 5) the voltage appearing across a matched load at the receive antenna. The voltage and electrical energy of the Loomis antenna is based on the generally accepted model of the electrical energy in the earth's atmosphere between the earth's surface and the ionosphere—a volume known as the “earth-ionosphere cavity,” which begins at the earth's surface and extends to approximately 70 km above the earth's surface. As far as I am aware, no one has made any estimate of the energy that the Loomis antenna could have extracted from the atmosphere or the response of the receive antenna to an electromagnetic pulse that could have been radiated from a Loomis antenna.

The Accepted Electrical Model of Earth-Ionosphere Cavity

Mahlon Loomis was aware that the earth and ionosphere constituted a large concentric spherical cavity that acted like a battery, with the ionosphere being positively charged and the earth being negatively charged. He also believed, quite incorrectly, that there was a horizontal flow of electrical current at an altitude above the clouds that he could tap into by using a kite with a conducting patch that would act as an electrode. Furthermore, he believed that when a wire leading downward from the electrode on one kite was grounded, it would produce or disturb the flow of current to another electrode situated on a second kite at the same altitude as the first kite, and that the disturbance would be conducted by a wire from a patch on the second kite to a galvanometer situated on the ground at a large distance from the site of the first kite.

Indeed, the earth-ionosphere does constitute a large “battery” in which the

ionosphere is positively charged and the earth is negatively charged, but from ongoing analyses and measurements that have taken place over more than a century, it is now known that there is a global flow of positively charged particles downward from the ionosphere to the earth's surface—not in a horizontal direction as Loomis believed. One of the most comprehensive and inclusive references describing the earth's electrical environment was prepared by the American National Research Council in 1986.¹⁸ There are also excellent and more recent online papers that summarize the state of knowledge of this electrical environment.¹⁹

The positively charged ionosphere and negatively charged earth acts like a charged capacitor or “battery” that produces an electric field in the earth-ionosphere cavity (see Fig. 6).²⁰ It is generally believed that this “battery” is continuously recharged by the large number of thunderstorms that are active at any given time around the earth (1000 to 2000). The key measurable quantities that determine the basic electrical parameters of the earth-ionosphere cavity as a function of altitude are the current density, the electric field, the air conductivity, and the relaxation time. The values for these parameters in fair-weather conditions are dramatically different

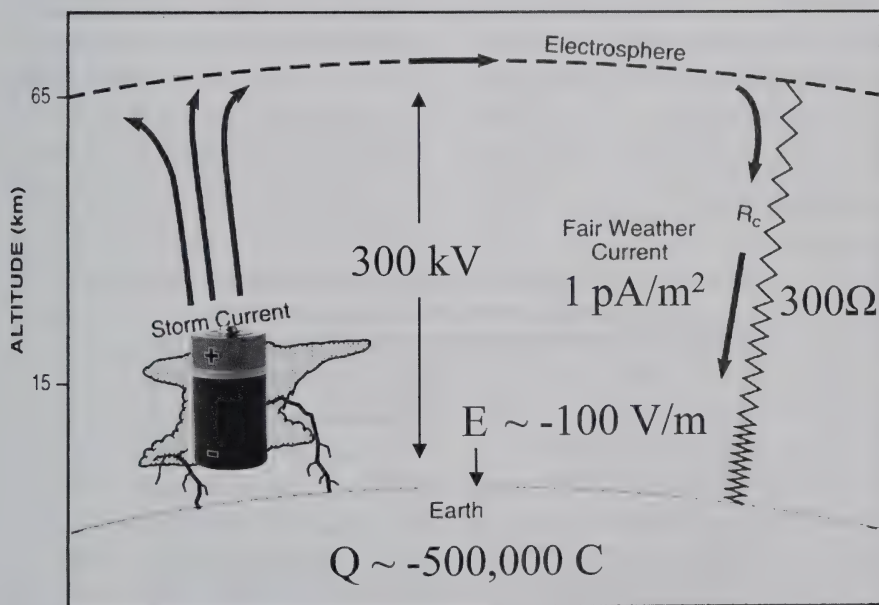


Fig. 6. A simple conceptual model of the global electric circuit consists of positively charged ionosphere and negatively charged earth that acts like a charged capacitor or “battery” producing a flow of electric current from the ionosphere to the earth, which results in a nominal potential gradient (electric field) of 100 V/m in the vicinity of the earth's surface. (Adapted from Colin Price, “The Global Atmospheric Electric Circuit”)

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from those that obtain during thunderstorms. The fair-weather conditions are of interest for the Loomis system, since the Loomis system will not work during thunderstorms.²¹

Measurable Fair-Weather Electrical Parameters

The measurable fair-weather parameter values of interest are a function of many variables such as altitude, location on the earth, time of day and season, particulate matter in the air, and humidity. Nominal values of the key fair-weather parameters used in later calculations applicable to the region of interest near the earth's surface where a kite might fly are listed in the upper portion of Table 1. They are taken from a table appearing in the document published by the National Academy of Sciences.²² The parameters in the lower half of this table, which are derived from the measured parameters, apply to what is known as the "global electric circuit."

Current Density: Researchers have made many measurements of the current densities that flow radially downward from the ionosphere to the earth's surface during fair weather conditions.²³ These measurements show that the nominal vertical current density is extremely low—on the order of 1 pA/m².

Electric Field: Researchers have made many measurement of the electric field at various altitudes between the earth's surface and the ionosphere. One method of determining the electric field near the earth's surface is to place a plate parallel to the earth's surface at a known height and use a high-impedance voltmeter or electrometer to measure the potential of the plate. The electric field in boundary layer of the earth's surface up to about one kilometer has been found to be relatively constant, with a value of negative 90-120 volts/m. The electric field then begins to decrease with increasing altitude until it approaches

Table 1. Typical fair-weather electrical parameters that obtain near the earth's surface used in later calculations.

Parameter	Typical Values	Units
Current density	1	pA/m ²
Electric Field	-100	V/m
Conductivity	10 ⁻¹⁴	mho/m (S)
Relaxation Time	5-30	minutes
Cavity Potential	300	kV
Global Current	2000	A
Global Resistance	300	Ω
Earth's Charge	-500,000	C
Global Power	300	MW

zero at the sensible ionosphere, which is the portion of the ionosphere beginning at approximately 70 km, known as the “electrosphere,” where the air becomes highly conductive and the electric field is essentially zero.

This electric field produces equipotential surfaces parallel to the earth’s surface. The potential difference between earth’s surface and a point above the earth’s surface up to a kilometer is approximately 100 V/m times the height in meters. A conductor placed in the earth’s atmosphere at some altitude will attain the same potential as the potential at that altitude. The potential of the atmosphere difference between the earth and such a conductor can be measured directly by several instruments, including a high-impedance electrometer.

Conductivity and Relaxation Time: The electrical conductivity of the air in the vicinity of the earth’s surface has been measured in many places, and the nominal value of the conductivity is on the order of 10^{-14} mhos/m. While the air is an extremely poor conductor, the conductivity is finite and does play a role in determining the relaxation time of disturbances in the atmosphere. The relaxation time has been measured at many altitudes, and in the region near the earth’s surface it has found to vary between 5 to 40 minutes, the actual value depending on several factors, primarily levels of particulate matter. The relaxation time determines the time that it takes for disturbances in the electrical environment to relax to equilibrium

conditions. One method of measuring the relaxation time is to measure the time evolution of the potential of a plate or wire placed parallel to the earth surface; the time constant τ can be extracted from the charging data, which has a time evolution similar to the charging of a capacitor in an RC circuit.

Global Electrical Parameters

The key global parameters of interest are the potential difference between the earth’s surface and the ionosphere, the global flow of current to the earth’s surface, the global resistance between the earth and the ionosphere, the total power delivered by the global current flow, and the total negative charge residing on or at the earth’s surface. The potential difference between the earth and ionosphere is calculated by integrating electric field measurements as a function of altitude from the earth’s surface to the ionosphere, resulting in a nominal value on the order of 300 kV. The total current flowing from the ionosphere to the earth worldwide is determined by multiplying this current density by the area of the earth, 510 million km², which results in a total nominal current of about 1000 amperes. The total power dissipated in the earth-ionosphere cavity by the current flowing from the ionosphere to the earth is nominally 300 megawatts, which is calculated by multiplying the total current flowing by the potential difference between the earth and ionosphere. The nominal resistance between the earth’s surface and ionosphere is 300 ohms, which is calculated by dividing the potential difference by

the total current. The nominal charge residing at or near the earth's surface is approximately a negative 500,000 coulombs, which is calculated using the equation $Q = 4\pi\epsilon_0 ER^2$, where R is the earth's radius, 6371 km, and E is the electric field, -100 V/m.

The global parameters are not directly used in calculations here, but they are certainly of interest. For example, the total power that is produced by the earth-ionosphere cavity in fair weather is only about 300 megawatts, the size of a single large fossil-fuel power plant. Given that the area of the earth's surface is 510 million square kilometers, the total power available from the electrical environment in each square kilometer of the earth's surface is only about a half a watt. On a steady state basis, the power extracted by the single wire and small conducting mesh of the Loomis kite is a small fraction of that amount.

Three Important Takeaways from the Electrical Model Earth-Ionosphere Cavity

The three most important takeaways from this discussion of the electrical model of the earth-ionosphere cavity are as follows:

- A conducting wire, flat plate, or other similar conducting object with a small vertical dimension placed horizontally in the earth's atmosphere near the surface of the earth at a height h will become positively charged until the potential of the conductor with respect to the earth is equal to the product of the earth's electric field (100 V/m in the vicinity of the earth) and the altitude h in meters.

- Positive charge is accumulated by conductors placed in the earth's electrical environment until the charge Q equals CV where C is the capacity of the conductor with respect to ground and V is the potential of the conductor with respect to ground.
- The time for a conducting object, such as a wire or flat plate, exposed to the earth's natural electric field in the atmosphere to reach its equilibrium potential after being grounded to the earth's surface is between 5 and 40 minutes.

Maximum Voltage and Energy Per Pulse Radiated and Received by Loomis Kite Antennas

The starting point for determining the voltage and energy radiated by the Loomis antenna as a result of a discharge of the kite wire to ground is to determine the total energy that could be collected by a Loomis antenna prior to a discharge. The energy stored on the Loomis antenna is $\frac{1}{2}CV^2$, where C is the capacity with respect to ground of the 40×40 cm conducting mesh plus the wire attached to the conducting patch, and V is the voltage of the kite wire and mesh with respect to ground. As a prelude to determining the voltage and energy, the Loomis kite wire and mesh capacity with respect to ground will be estimated first.

Kite Wire and Mesh Capacity

An approximate value for the capacitance of a vertical wire of length l and diameter d is given by $C = 2\pi\epsilon_0 l / \ln(2/D)$, which is valid with two assumptions: 1) the ratio of the wire diameter to length of the wire

($D = d/l$) is much less than one, and 2) the gap between the wire and ground is much less than the wire length.²⁴ For the parameters of interest to the Loomis antenna ($l = 183$ m, $d = 0.001$ m, and $D = 5.5 \times 10^{-6}$), the capacity of the antenna according to this formula is 795 pF.

As a sanity check, the capacity of a monopole antenna can also be calculated from the resonant frequency and the inductance of the vertical wire, which is much easier to estimate than the capacitance. The approximate inductance of a vertical wire is simply $\mu_0 l$, which is 2.3×10^{-4} H for a 183-meter wire. At resonance, the impedance of the inductance and capacitance are equal, so that $f = 1/(2\pi\sqrt{LC})$. Using the resonant frequency of 410 kHz and the inductance of the antenna wire as 2.3×10^{-4} H, the approximate capacity is 655 pF, reasonably close to the value of 795 pF determined by using the above equation for the capacitance of a vertical wire. (The calculation using the resonant frequency does not take into account the fact that the resonant frequency of a monopole depends on its diameter and the resonant wavelength is not exactly four times the antenna height; also the inductance of a vertical wire is not exactly $\mu_0 l$.)

Turning to the 40×40 cm wire gauze, the capacity of a disk C_{DISC} of radius R located at a height h far from the earth's surface ($h \gg R$) is given by the expression $C_{DISC} = 8\epsilon_0 R$.²⁵ Assuming the 40 by 40 cm gauze can be represented disc with radius of 20 cm, its capacity is $8\epsilon_0 \times 0.2 = 14.6$ pF. This capacity is negligible compared to the antenna capacity of 795 pF. For purposes of the bounding

calculation, this capacity will be added to the antenna capacity, resulting in a total capacity of 810 pF, which will be used as the total capacity for Loomis's kite wire.

Maximum Voltage and Energy per Pulse Accumulated by a Loomis Antenna

The upper bound to the voltage with respect to ground that a conducting object can reach when placed in the earth's natural electric field is the equilibrium potential at the altitude of the highest point of the object. Since the Loomis kite had an altitude of 600 feet, or 183 meters, the upper bound to the equilibrium potential of the Loomis antenna is the product of the nominal electric field of 100 V/m and the maximum kite altitude of 183 m, or 18 kV. In reality, the kite wire would obtain that potential only if the entire length of the antenna wire and kite were located at 183 meters. The actual potential of the Loomis wire, which extends from the ground to an altitude of 183 meters, is something less, but there is no known methodology to determine what the actual potential of a Loomis antenna is in the vertical configuration. Measurements described later suggest that maximum voltage of the antenna may reach only about one-third to one-half of the atmospheric potential at the highest point of the kite.

In the spirit of an upper bound calculation, it will be assumed that the capacity of the kite/mesh is 810 pF and the voltage is 18 kV. In that case, the upper bound to the energy \mathcal{E} per pulse and charge stored on the Loomis antenna prior to a discharge is:

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$\mathcal{E} = \frac{1}{2}CV^2 = 0.5 \times 810 \times 10^{-12} \times (1.8 \times 10^4)^2 = 0.13 \text{ joules},$

$Q = CV = 810 \times 10^{-12} \times 1.8 \times 10^4 = 1.5 \times 10^{-5} \text{ coulombs}.$

The Maximum Energy and Voltage Received by a Loomis Antenna

The upper bound to the energy of 0.13 joules collected by the Loomis kite before a discharge is used to bound the energy transmitted by one kite and received by another identical kite. From the received energy, an upper bound to the voltage appearing across a load matched to the radiation resistance of the antenna is then calculated for purposes of comparing with galvanometer sensitivity thresholds. The upper bounds are estimated by modeling the Loomis antennas as two ideal dipoles with lengths of two times the monopole height to match the resonant wavelength of the Loomis antenna. This model follows the same approach that Harald Friis used to relate the power transmitted by one antenna to the power received by another antenna

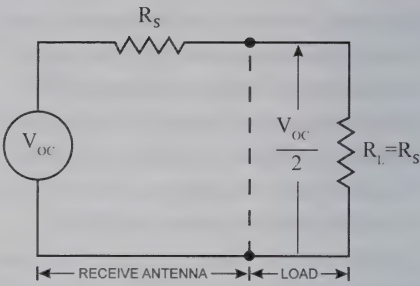


Fig. 7. An equivalent circuit for a dipole antenna with a load matched to the radiation resistance of the source.

at a distance d when both are resonant at the same wavelength.²⁶ The voltage across the load is modeled by an equivalent circuit of the antenna receiver and matched load shown in Fig. 7, and it is assumed that half the received energy is delivered to a load equal to the radiation resistance of an ideal dipole at resonance. It is also assumed that there are no i^2R losses of energy in either antenna circuit and no attenuation by the intervening atmosphere. The formulas used in these calculations with the numerical results are shown in Table 2.

Table 2. Bounding calculations for the transmission and reception of an electromagnetic pulse for a pair of Loomis antennas located 20 miles (32 km) apart

Transmit Antenna		Receive Antenna	Receive Antenna Load	
Energy Stored	Energy Transmitted	Energy Density at Receive Antenna	Energy	Open Circuit Voltage
$\mathcal{E}_s = \frac{1}{2}CV^2$	$E_t = 50\% \text{ of } \mathcal{E}_s$	$e_r = E_t G / (4\pi d^2)$	$E_r = e_r G \lambda^2 / 4\pi$	$V_{OC} = (E_r R_{RAD} / \Delta t)^{1/2}$
$\mathcal{E}_s = 0.13 \text{ J}$	$E_t = 0.065 \text{ J}$	$e_r = 8 \times 10^{-12} \text{ J/m}^2$	$E_r = 5 \times 10^{-7} \text{ J}$	$V_{OC} = 2 \text{ V}$

$G = 1.6, R_{RAD} = 73 \, \Omega, \Delta t = 10 \, \mu\text{s}, \lambda = 732 \text{ m}, d = 32 \text{ km}, C = 810 \text{ pF}, V = 18 \text{ kV}$

Summary of Bounding Calculations

It was determined by early researchers that the fraction of energy generated by a spark source that was actually radiated is less than ten percent.²⁷ However, for purposes of bounding calculations it will be assumed that fifty percent of the energy stored on the antenna prior to discharge is radiated into 4π steradians with a gain of 1.6 in the direction of the receive antenna. The receive antenna has an effective capture area of $G\lambda^2/4\pi$,²⁸ and half the collected energy is delivered to a load matched to the radiation resistance of 73 ohms—the maximum energy that can be transferred from a source to a match load. The basic Reiss formula for relating the energy received, E_r , to the energy transmitted, E_t is $E_r = E_t G_t G_r (l/4\pi d)^2$. Note that the factor $(l/4\pi d)^2$ is called the “free space path loss,” which for the Loomis antenna is 3.3×10^{-6} .

The open circuit voltage in the right hand column of the table can be scaled to other conditions by recognizing that the open circuit voltage is inversely proportional to the distance between the antenna, d , and directly proportional to the square root of the transmitted energy, E_t . The open circuit voltage for the 20-mile (32 km) distance between the two Loomis antennas on two Blue Ridge Mountain peaks is about two volts. Coincidentally, 1 to 2 volts is the nominal threshold to trigger a sensitive coherer of the type Marconi used in the late 1890s. It will be shown in a later section that two volts is far too small to register on even very sensitive dc galvanometers of the day for very short pulses of electromagnetic

radiation with pulse widths on the order of tens of microseconds or less.

Charging Time for the Loomis Kite Antenna

The energy per pulse delivered to the Loomis antenna is not the only parameter needed to characterize the performance of the Loomis system as a method of wireless telegraphy. The pulse repetition rate, or frequency (PRF), is equally important because it determines the word rate in a communication system that utilizes spark discharges. Both the charging time of the Loomis antenna and the effect of the charging time on the maximum word rate possible in a telegraphy system using Morse code are explored in this section.

Charging Mechanisms for the Loomis Antenna

When the wire on the Loomis kite is grounded, the time to discharge the kite is less than ten microseconds, but the time for the kite to recharge to a voltage that can produce the next successive pulse is not insignificant. After each discharge, positive charge accumulates on the antenna wire and conducting patch until the wire reaches its equilibrium potential. There are two possible mechanisms that recharge a conductor in the atmosphere after a discharge: 1) the direct flow of positively charged ions from the ionosphere to the earth that directly strike the antenna at a rate of approximately 1 pA/m^2 , and 2) flow of charged particles through the slightly conducting air influenced by the electric field in the vicinity of the conductor.

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The flow of positive ions downward from the ionosphere that intersect the wire is not the primary means of charge collection because the current density is so low.²⁹ By all accounts, equilibrium is reached much sooner by the balance of conduction currents of positive and negative charged particles in the highly insulating, but still slightly conducting atmosphere. For example, the downward flow of current from the ionosphere is about 1 pA/m. The kite wire with a diameter d of about 0.001 meters and a length l of 183 meters has a lengthwise projected area (dl) of 0.183 m². The patch has an additional projected cross sectional area of 0.16 m², so the total cross sectional area exposed to the downward current would be no more than 0.4 m². Since the total current intersecting the wire and kite patch is on the order of 1 pA, the time to accumulate the charge of 1.5×10^{-5} C calculated previously would be 1.5×10^{-5} C divided by 10^{-12} amperes, or 1.5×10^7 seconds.

According to the literature on the subject of atmospheric electricity, the time for an isolated conducting surface to reach the potential of the surrounding atmosphere by means of conduction currents is known as the “relaxation time” of the atmosphere, often denoted by τ .³⁰ The relaxation time is equal to ϵ_0/σ , where ϵ_0 is the permittivity of free space and σ is the conductivity of air. While the conductivity of air is very low in the vicinity of the earth’s surface (in the region below several miles above the earth’s surface), it is still finite, and it has a nominal value of approximately 10^{-14} mho/m, depending on the density of particulate matter in the air

and possibly other factors such as humidity. For the nominal air conductivity of 10^{-14} mhos/m, the relaxation time in the atmosphere near the earth’s surface is on the order of $8.85 \times 10^{-12}/10^{-14}$ seconds, or about 17 minutes.

The nominal relaxation time in the vicinity of the earth has been measured directly by many investigators and found to vary between 5 and 40 minutes.³¹ That means the time for recharging Loomis’s kite after a discharge might be several times 5 to 40 minutes—a very long time in the world of transmitting messages by wireless telegraphy using successive spark discharges.

Very few papers were found in the literature providing data on the direct measurement of the time it takes a conductor in the natural environment at its equilibrium potential to charge back up to its original potential after being discharged to earth by a ground wire. A search of the literature uncovered a paper by Bennett and Harrison,³² who reported a measurement of the time for an isolated horizontal twenty-meter-long wire positioned one meter above ground to recharge to its original potential after grounding by another wire. They used a high impedance electrometer to measure the time evolution of the potential, although they did not give any specifications about the resistance or capacitance of the electrometer they used. The purpose of their experiment was to measure the change in potential of the wire over a time long enough to extract charging time constant, τ , assuming the charging time is in the form of an exponential $V = V_0(1 - e^{-t/\tau})$. The initial value of the

potential on the wire before the discharge was not reported, nor was there any attempt to measure the time to reach the final equilibrium potential. Nevertheless, the data clearly show that the time for this particular wire to reach the original potential would have been well in excess of 1740 seconds (29 minutes), 1740 seconds being the time at which a recording of the potential ended (see Fig. 8). Note that the potential gradient plotted in the figure is actually the measured electrometer voltage divided by the height of the wire over the ground, which was one meter. Thus, the potential gradient (electric field) in this case is numerically equal to the voltage measured by the electrometer.

By comparison, Marconi's 10-inch Ruhmkorff coil, which was interrupted by a vibrating mechanical contact, was

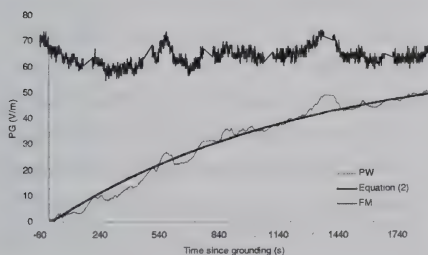


Fig. 8. Harrison and Bennett may have been the first to report a measurement of the charging time of a long wire over a ground plane immediately following a discharge, from which they extracted the charging time constant—the time required to reach 68% of the final wire potential. The top line is the electric field measured by a “field mill” (FM) technique, and the light wavy line is time evolution of the wire potential, after grounding, as measured with an electrometer. (Bennett and Harrison, *Rev. of Sci. Instr.*, Vol. 77, 2006).

able to produce 50 to 100 pulses per second, thereby allowing Marconi to transmit 15 to 20 words per minute in his 1898 demonstration at Bournemouth. The impact of the time delay between successive radiated pulses on communication by means of wireless telegraphy is described next.

Effect of Charging Times on Word Rates

The ability to produce a spark only once every few minutes would have a devastating impact on the application of Loomis's concept to communication of intelligence by wireless telegraphy. To calculate the word rate as a function of the time interval between sparks, consider the “standard word” of Morse code, PARIS, which has 50 dot-equivalent spaces (see Fig. 9). A dot-equivalent space, or “dot space” is defined as the time allotted to a single dot of Morse code: a dash is three dot spaces, the space between dots and dashes in a single letter is one dot space, the space between letters is three dot spaces, and the space at the end of each word is seven dot spaces.

To transmit one standard word per minute requires a pulse repetition rate, at a minimum, of 50 pulses per minute. While the total number of pulses required per word is less than 50, the pulse rate is still 50 pulses per minute in order to produce the dashes in a timely fashion. Significantly, multiple dots are necessary to convey a single dot in the presence of noise (such as static or electrical noise from sources close to the receiver), but in the spirit of a best-case assessment, it will be assumed that only one discharge is necessary to convey a

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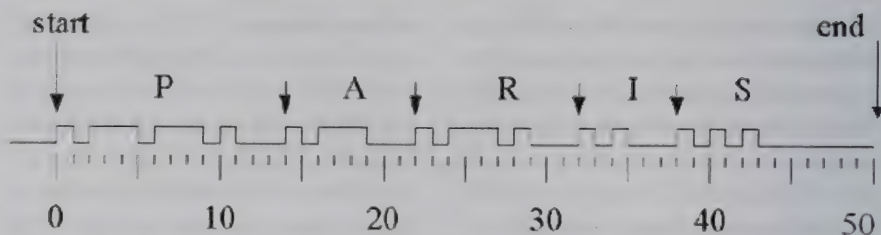


Fig. 9. The word “PARIS” is often used to define word speed of Morse code in words per minute (wpm). A dash is defined as three dot spaces, the space between dots and dashes in a letter is defined as one dot space, the space between letters is defined as three dot spaces, and the space at the end of each word is defined as seven dot spaces—for a total of 50 dot-equivalent spaces per word. (<http://www.qsl.net/w8rit/cw.htm>)

single dot of Morse code. In that case, the maximum word rate possible as a function of the time between each transmitted pulse is shown in Fig. 10. Note that the word rate in this figure is expressed in terms of “minutes per word” rather than the usual “words per

minute.” From this figure, it becomes obvious that a five-minute (300-second) spacing between each transmitted pulse results in a word rate of one word every 250 minutes—that is, about one word every 4.2 hours.

This calculation assumes that every dot is received and there is no noise from static, sources of electrical noise near the receiving station, thunderstorms, or other sources. Either a missed dot or a single dot of noise at a rate of only one pulse every two hours could render even a single word unintelligible. By comparison, early wireless telegraphers used a Ruhmkorff coil as a spark source with pulse repetition rates of 50 pulses per second (pps) or more to achieve 20 words per minute. The time for a dot space at 20 wpm is $1/20$ of a second, or 0.05 seconds. At 50 pulses per second, the number of pulses per dot space is 2.5 and at 100 pps it is 5 pulses per dot space.

If the pulse rate is really limited by the charging of the kite to less than one pulse per five minutes, which translates into just over one word every four hours, then Loomis’s claim of telegraphing

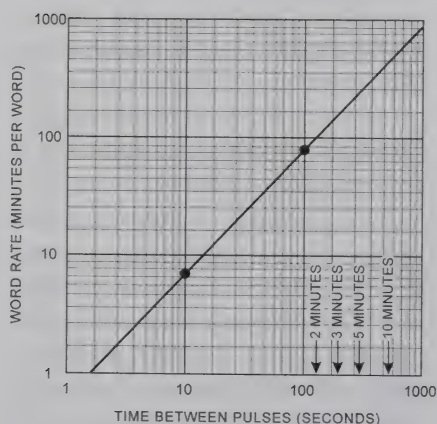


Fig. 10. The maximum word rate possible (y-axis) is shown as a function of the time delay between each successive discharge (x-axis); it is assumed that only one discharge is needed for each dot and three discharges are needed for each dash. Note that the word rate in this graph is expressed in terms of minutes per word rather than words per minute.

actual messages by any method of wireless telegraphy using atmospheric electricity is clearly false. Because of the dearth of data on the charging time for antenna-like structures, and

the importance of the charging time on the conclusions of this study, a significant part of this study was directed at measuring the charging times and potentials of antenna-like structures.

PART III: MEASURING CHARGING CHARACTERISTICS OF ANTENNA-LIKE STRUCTURES

While most scientific books and scholarly articles agree that a conductor placed at a selected height on an equipotential surface of earth's atmosphere will come to that potential within a few relaxation time constants, the remaining issues are: 1) what is the equilibrium potential of a wire that is placed perpendicular to equipotential surfaces of the atmosphere (i.e., perpendicular to the earth's surface), and 2) how long does it take for a Loomis-type antenna to recharge to a potential that is capable of transmitting an electromagnetic signal to a useful distance. To address these issues, a modest experimental program was undertaken to determine the charging rates and potentials for both horizontal and vertical wires, configurations representing three-dimensional objects, and configurations with sharp points believed by many to enhance the collection of electrical energy from the atmosphere.

The experimental program addressed three basic configurations: 1) a 30-meter long bare copper wire stretched horizontally between two poles three meters high, 2) a bare wire affixed to a 3-meter pole that was oriented vertically at a

slight angle to the normal, and 3) a small rectangular configuration approximately $50 \times 50 \times 100$ cm on a side that was suspended from a rope at a height of 3 meters. In all cases, the wires were isolated from the suspension rope by ceramic standoff insulators. The experiments were performed over a watered grass lawn with a one-meter copper rod driven into the wet soil that served as the ground plane.

Measurement Methods

Several different methods have been devised for measuring the potential of a conducting object placed in the earth's natural electrical environment, most notably by either a direct measurement of the object potential with a high-impedance electrometer or by a device called an electric field mill, often abbreviated as FM.³³ Each technique has its advantages and disadvantages, but the electrometer has the advantage of being able to measure the time evolution of the potential of virtually any conducting object produced by the earth's electrical environment after being grounded to the earth's surface. The field mill uses two small electrodes that rotate to generate

alternate positive or negative signals that can be amplified.

The problem with an electronic electrometer is that the input impedance has to be greater than 10^{15} ohms to avoid loading the object being measured because the impedance between the electrical environment of the atmosphere and conducting objects is on the order of a few times 10^{14} ohms. Since the charging time may be long, the accumulated charge will discharge through the electrometer unless its impedance is much greater than the impedance of the atmospheric “contact impedance” to the object.

The Electrometer Measurement Method

The original plan was to use a high-impedance electrometer to measure the time evolution of the electric field, just as others have done when studying atmospheric electricity. However, with one notable exception, virtually all commercially available electrometers have an input impedance specification no greater than $2 \times 10^{14} \Omega$, which is not high enough to make accurate measurements.³⁴ It turns out that the input impedance for an electrometer must be greater than $10^{15} \Omega$,³⁵ something I found out for myself after purchasing and experimenting with a relatively inexpensive electrometer having an input impedance spec of $10^{14} \Omega$.

Another problem with the electrometer is the input capacity, which is typically in the range of 15 to 30 pF. When measuring the potential buildup on smaller objects with capacities on the order of the input capacitance of the meter electrode, significant errors

are introduced in the measurement of the time to buildup the potential. In essence, the object has to accumulate enough charge to raise the potential of both the object itself and the electrometer, which takes a longer time. It is easy to adjust the magnitude of the potential reading of the electrometer to account for the probe capacity, but it is more difficult to adjust the time history of the buildup as well. Clearly, a simple, completely non-perturbing method of measuring the potential buildup of conductors would be most welcome.

The Digital Storage Oscilloscope Measurement Method

It soon became obvious that a high-speed, digital storage oscilloscope could be used to measure the voltage of an object at any point in time after a discharge without having any connection of any kind to an object under test before making the measurement (except, of course, for one or two ceramic insulators used to hold the object in place). The oscilloscope concept eliminates both the electrometer and the vertical wire needed for the connection to the electrometer. The vertical wire, which extends through different equipotential layers of the atmosphere between the wire and ground, can also perturb the voltage of the horizontal wire. The input capacitance of the scope will load the wire under test, just like the electrometer—but only at the time it contacts the wire to make the voltage measurement, not during the entire time the object is charging.

This measurement technique was tested in the lab with a capacitor having

16 pF—the lower limit to the capacity of all objects tested. A scope measurement of the voltage across a 16 pF capacitor charged to 10 volts just before touching the capacitor with a scope probe of 17 pF is shown in Fig. 11; the measured scope voltage reads 4.8 volts. To obtain the actual voltage V , the voltage V_{SC} measured by the scope across the capacitance C_{CAP} , must be adjusted for the probe capacity C_{PRB} as follows: $V = V_{SC} \times (C_{PRB} + C_{CAP}) / C_{CAP} = 4.8 \times (16 + 17) / 16 = 9.9$ volts. This technique does not load the object under test during the entire time the charge builds up, so the charging time is not perturbed, and the voltages deduced from scope measurements, even for the smallest capacitances of interest, are demonstrably accurate.

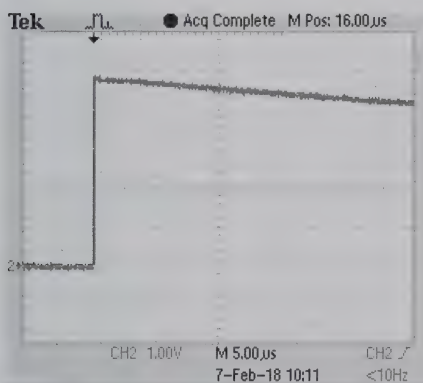


Fig. 11. This oscilloscope method of measuring the voltage on a wire of low capacity was tested in the lab with a 16 pF capacitor—the lower limit to the capacity of all objects tested. A scope measurement of the voltage across a 16 pF capacitor charged to 10 volts just before touching the capacitor with a scope probe of 17 pF produced approximately 5 volts, the voltage expected from a scope probe with a capacity equal to the capacity of the capacitor under test. (Vertical scale: 1 V/div., horizontal scale: 5 µs/div.)

Charging Measurements

Results for Horizontal Wires

Theoretically, the charging time of an isolated conductor depends on the ratio of the local dielectric constant and air conductivity, not the specific geometry. Nevertheless, the geometry selected to quantify the charging time of the Loomis antenna in a horizontal position was a bare, twisted copper wire with a diameter of 1 mm, which was Appleby's best guess of what Loomis would have used. In a numbers of tests, 30 meters of wire was suspended between two poles at a height of 3 meters using ceramic insulators (see Fig. 12). The time evolution of the potential beginning immediately after a discharge was made first by using a Pasco Model ES-9078 electrometer with an input impedance of $10^{14} \Omega$ and an electrode capacity of 27 pF. (The oscilloscope method is also shown in this figure, but the two are not used at the same time.) A typical "good result" is shown by the dots in Fig. 13. A "good result" is when the measured potential increases monotonically, and a "bad result" is when the potential reverses itself during the measurement period—most likely because the earth's electric field around the wire drops during the relatively lengthy measurement period. An example of the variation in the earth's electric field obtained by Bennett and Harrison is shown in Fig. 14,³⁶ where it is evident that relatively large swings in the electric field can occur in a matter of minutes and remain changed for even longer times.

The equilibrium potential before the discharge could not be determined

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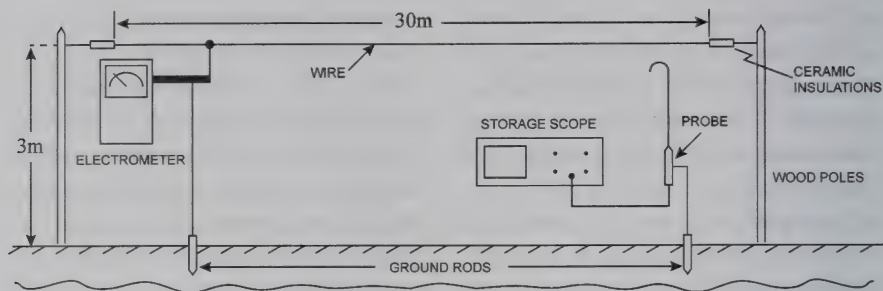


Fig. 12. Two separate techniques were used to measure the time evolution of the charging by the natural environment of a 30-meter horizontal wire situated 3 meters above the ground: 1) the classical approach using a high-impedance electrometer connected to the wire as it is charges; this technique loads the wire under test, and 2) a novel non-loading method using a storage oscilloscope that is touched to the wire only at a selected certain time interval following a discharge.

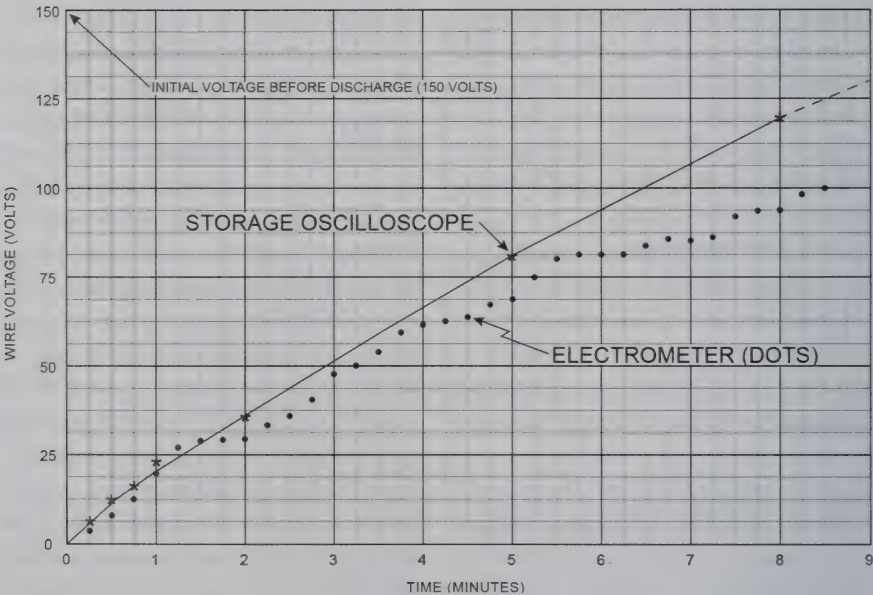


Fig. 13. This is one of the many measurements made of the voltage as a function of time after grounding the 30-meter wire at a height of three meters using both the electrometer and the oscilloscope methods separately give about the fastest charging times measured. The time to reach 68% of the final potential of 150 volts is approximately 7 minutes or 420 seconds—which corresponds to a word rate for Morse code transmission of 300 minutes per word.

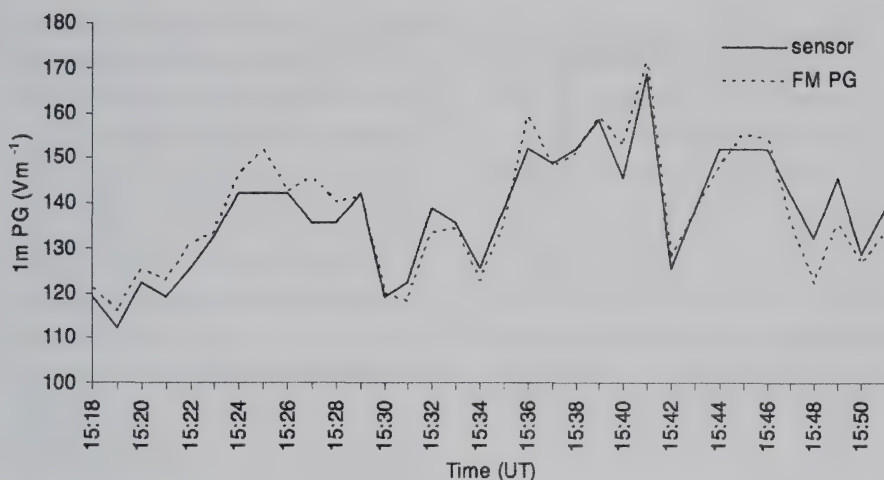


Fig. 14. The natural electric field near the earth's surface can vary by as much as 30–40% within one-half hour. (Bennett and Harrison, *Hist. Geo- and Space-Sci.*, p. 14)

by the electrometer since the wire voltage exceeded the voltage range of the electrometer (99 volts). However, the potential was recorded just prior to the discharge of the wire by the oscilloscope method and found to be 150 volts (see Fig. 15 for a typical scope trace). The probe capacity is about 10% of the wire capacity, so the scope readings must be adjusted upward by about 10% to arrive at the actual voltage. The time to reach 100 volts, which is less than two-thirds of the potential before discharge, was $8\frac{1}{2}$ minutes—a huge delay time between successive discharges for a source used in telegraphy.

Measurements were then made using the oscilloscope measurement method. The isolated wire was allowed to charge up for at least 45 minutes to establish the approximate equilibrium voltage before discharge. The probe was touched to the wire, with a measured capacity of 180 pF,

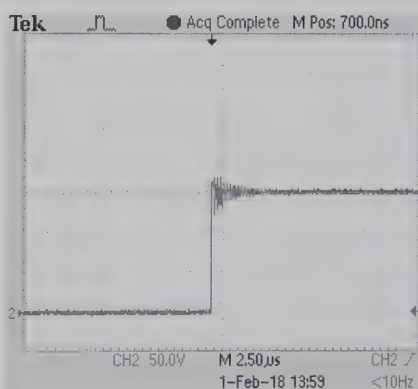


Fig. 15. After accumulating charge for about an hour before performing experiments on the 3-meter vertical wire, the scope trace on the 30-meter horizontal wire was charged to 150 volts. This scope trace must be adjusted upwards from 150 volts to 165 volts to account for the probe loading on the 30-meter wire with a measured capacity to ground of 180 pF. (Vertical scale: 50 V/div., horizontal scale: $2.5 \mu\text{s}/\text{div.}$)

and the trace was captured revealing the maximum voltage. (Scope measurements were made when the initial potential of wire was approximately 150 volts, so that it matched the initial potential of the wire just before measurements were made with the electrometer.) A series of measurements of the wire voltages were then made immediately following discharges at 15, 30, 45, 60, 120, 300, and 480 seconds after grounding. Three measurements were made at each of the seven time intervals after discharge. There were variations among the three successive measurements made at each time interval, but when averaged, the resulting voltage for each successive time interval could easily be distinguished from voltages obtained at other time intervals.

The scope data points are also plotted in Fig. 13 using the “star” symbol, which represents the average of the three measurements at each time interval. The raw measurements are plotted in this graph before making adjustments to account for probe capacity. Since the probe capacity was 17 pF and the measured capacitance of the wire was 180 pF, all of the measured voltages must be adjusted upward by approximately 10%. It is clear that the voltage measured by the scope diverges from the voltage measured by the electrometer, with the scope data increasing faster than the electrometer data. Thus, the electrometer data suggests a longer charging time than the scope data, but in fact, the electrometer was loading the wire, giving the false impression that the charging time was longer.

If the Loomis antenna had a voltage of 18 kV, and the smallest acceptable

voltage to produce significant electromagnetic radiation is half that amount—say 10 kV—then, according to Fig. 13, the antenna would recharge to half its maximum value (75 volts out of 150 volts) at about 4½ minutes after a discharge. This is still a large delay time for telegraphic purposes, although it is slightly less than the relaxation time.

Results for Vertical Wires

Another key issue for the Loomis antenna is determining the maximum voltage, charge, and energy that can be accumulated by a *vertical* antenna exposed to an atmospheric potential that varies linearly between 18 kV at the kite altitude of the Loomis antenna and zero at ground level. In the bounding calculation presented in the last section, an assumption was made that the vertical antenna, with a maximum height of 183 meters, would charge up to the maximum atmospheric potential of 18 kV at 183 meters. But this will happen only if the conducting patch *and* the entire antenna wire were situated at the kite altitude. Clearly, the actual voltage (and the associated charge and energy produced by that voltage) must be less than the atmospheric potential at kite altitude, but there is no proven way to make a more realistic bound than to assume the antenna voltage is equal to the atmospheric potential at the top of the antenna.

To determine how much of an error is made by assuming potential of the wire at equilibrium is equal to the equipotential surface at the kite altitude, a vertical wire of 3 meters in length, canted at a slight angle to a line normal to the earth's

surface, was stretched between a pole and a stake about 6 inches from ground (see Fig. 16). The wire was allowed to come to its equilibrium potential by waiting 45 minutes. Simultaneously, the 30-meter wire was positioned next to the vertical wire, also at a height of 3 meters, and allowed to come to equilibrium. The voltages of both wires were measured within 15 seconds of each other using the scope method by first touching the vertical wire with the probe and then the horizontal wire. Since the top of the vertical wire was at the same height as the entire horizontal wire, and since the two wires positioned next to each other and measured at essentially the same time, the two wires were exposed to the same field at the same time.

This experiment was repeated several times with essentially the same result. One set of measurements is shown in Table 3 where the measured voltages of both the horizontal and vertical wires are directly compared. Since the oscilloscope method was used to make these measurements, it was also necessary to measure the capacities of both wires with respect to ground in order to make the corrections necessary to account for the capacitive loading of the scope probe.

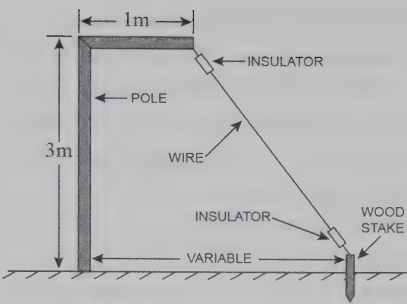


Fig. 16. The test configuration used for measuring voltage on the vertical wire. Note the ceramic insulators used to isolate the wire from the wood post and stake.

Both the raw scope voltages and the corrections in voltages to account for the probe capacity are shown in the table. The correction factors are different for the two wires because the capacitances of the two wires to ground are significantly different.

The actual voltage on the horizontal wire was slightly more than three times the voltage on the vertical wire. In this case (a short vertical wire), it is clear that assuming the equilibrium potential of a vertical wire in the atmosphere is equal to the free-space atmospheric potential at the *top* of the wire results in a relatively large overestimate of the actual voltage.

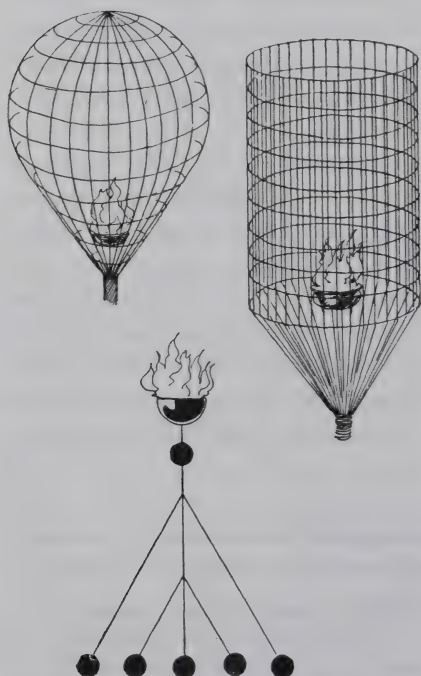
Table 3. Voltage measurements of a 3-meter length of a vertical wire compared to a 30-meter length of a horizontal wire suspended three meters above ground.

Antenna Wire	Wire Capacity	Voltage (Scope)	Voltage (Adjusted*)
Vertical (3 m)	25 pF	29 V	50 V
Horizontal (30 m)	180 pF	150 V	165 V

*Voltage adjusted to account for the 17 pF scope probe load.

Results for Cubical Objects

Loomis sketched other antenna configurations held aloft by balloons that he thought might collect electricity from the atmosphere more efficiently (see Fig. 17), although there is no indication that he used them in his experiment in the Blue Ridge Mountains. To address this possibility, volumetric objects consisting of cardboard boxes covered with aluminum foil suspended from a cord by a ceramic insulator at a height of three meters were also tested (see Fig. 18). These configurations were intended to be representative of three-dimensional objects that might be used to collect more charge. The



Methods Suggested by Loomis for the Harnessing of Electricity from the Atmosphere

Fig. 17. Loomis's sketch of balloon configurations designed for harnessing electricity from the atmosphere. (*Radio News*, Nov. 1922, p. 974)

test configuration shown in this figure includes sharp points, which many seem to believe might increase the efficiency of collecting charged particles from the atmosphere.

There was some variability in the data taken with and without needles, but there was no evidence that the charging times or voltages were noticeably different in the presence or absence of the needles. In theory, the final equilibrium voltage and charging times of an object should not be dependent on the details of configuration as long as it is exposed to the same atmospheric equipotential. That was confirmed by reviewing the data in the totality of the experiments performed on all the configurations. Of course, the charge collected by an object and current that flows when the object is grounded will vary depending on the size and shape because the charge collected at a given potential is proportional to the capacity of the object with respect to ground. However, the equilibrium voltage depends on the effective height of the

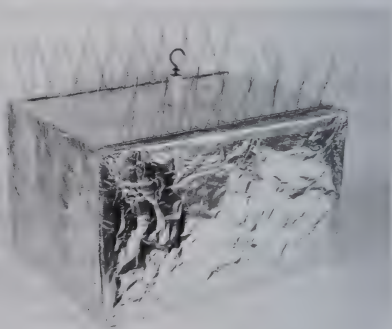


Fig. 18. An experimental configuration to determine if the charging voltage or charging time was influenced by the presence of sharp points to increase the local electric fields.

object, independent of capacity, and the charging time seems to be independent of height or capacity.

Realistic Upper Bound Potential for the Loomis Antenna

While it is now clear that the long charging time of the antenna is a show-stopper for using the Loomis method to communicate intelligence, it is still of interest to know how far an electromagnetic signal generated by the Loomis antenna could be detected. To the first order, the range is determined by the charging voltage and capacity of the antenna, not the charging time. While the capacity is known with some certainty, the voltage is not. There are at least four factors that determine the actual antenna voltage, the vertical orientation of the antenna wire addressed above being only one.

Another factor is the patch on the kite that has one third of the surface area of the antenna.³⁷ To the extent that potential is related to the convolution of the surface area and the atmospheric equipotential to which the surface is exposed, the potential may be higher than that suggested by the previous experiment on the vertical wire in the absence of a patch at the top. Perhaps a

more realistic reduction due to the vertical orientation of the Loomis antenna with a patch located on the kite would be a factor of two, rather than the factor of three suggested for a stand-alone vertical wire without a patch at the top.

Yet another factor is the 600-foot Loomis antenna wire attached to the kite, which would never remain directly overhead under any circumstances. If the kite is canted at only 30 degrees from the normal to the earth's surface by the wind, the maximum height would be 500 feet, or 150 meters, and the upper bound voltage would be reduced by one sixth.

Last but not least, according to Loomis, he waited exactly five minutes between each of his three transmissions in the Blue Ridge Mountains demonstration. Based on the data taken on the recovery time of long wires, the antenna voltage on Loomis's antenna would have recovered to only slightly more than 50 % of the final equilibrium value between five-minute discharges. That means the Loomis antennas in the Blue Ridge Mountains would have, at best, charged to only half of the upper bound voltage. As indicated in Table 4, a more realistic bound to the voltage of the antenna Loomis used in the Blue Ridge

Table 4. A more realistic bound to the potential of the Loomis antenna used his Blue Ridge Mountain experiment.

Reason for Reduction From Upper Bound	Reduction Factor	Antenna Potential
Upper Bound	None	18 kV
Kite Canted at 30 Degrees	0.83	15 kV
Vertical Wire with Patch	0.5	7.5 kV
Five Minutes of Charging	0.5	4 kV

Mountains is 4 kV volts, rather than the upper bound of 18 kV, the equilibrium potential of the atmosphere at the kite altitude. This represents a factor of 4.5

reduction in voltage and a factor of 20 reduction in radiated energy as compared to the values used in the upper-bound calculation of Part II.

PART IV: USING A GALVANOMETER AS AN INDICATING DEVICE

No treatment of the Loomis wireless system would be complete without addressing the fact that Loomis used a galvanometer as his detection device at the receiving station without any type of nonlinear detector, something that has been required in virtually all known wireless communication systems utilizing electromagnetic radiation. While it is clear that Loomis could not communicate intelligence with his system because of the long charging time, it is still of interest to know whether he could have transmitted and received just a single pulse in his experiment in the Blue Ridge Mountains.

Sensitivity of DC Galvanometers to Short Unipolar Pulses

Most galvanometers are sensitive to both dc currents and short unipolar pulses, unipolar meaning that the current flows in one direction. When a galvanometer responds to short pulses, it is generally said to be operating in a “ballistic mode,” which means that the galvanometer will respond to a very short pulse even when the pulse has passed thorough the galvanometer before the meter responds—much like a pendulum will move after a short hammer blow. It can be shown that the galvanometer response to a short

pulse is proportional to the time integral of the current flowing though the galvanometer, which is the total net charge flowing in one direction produced by the short current impulse.³⁸ Since the ballistic response is proportional to the total charge flowing through the galvanometer coils, the response is independent of pulse width as long as the amplitude of the current pulse increases commensurate with the decrease in pulse width, so that total charge flowing through the galvanometer is unchanged (see Fig. 19). For very short pulses with frequency content above the resonant frequency of the Loomis antenna, the response will roll off due to inductive and capacitive parasitics.³⁹ (This effect does not appear to be an issue below a few megahertz for most galvanometers.)

While the type of galvanometer that Loomis used is not known, judging from the galvanometer shown in Loomis’s earlier sketch of Fig. 3, it is possible that he used a sensitive galvanometer of the type designed for use as a sensitive null indicator in a Wheatstone bridge, an instrument that had gained popularity in the 1850s (see Fig. 20). The most sensitive galvanometer of the day was the galvanometer that William Thomson (later Lord Kelvin) designed in the 1850s

for use in submarine cable telegraphy. This type of galvanometer was of the astatic type, which used multiple magnets of opposite polarity suspended on a long wire or thread that nullified the

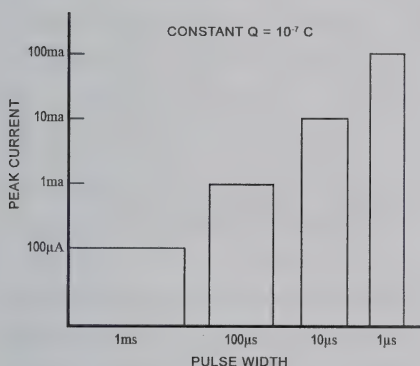


Fig. 19. These four pulses with increasingly shorter pulse widths have the same charge impulse ($Q = 10^{-7}$ coulombs) because the pulse amplitudes increase in proportion to the decrease in pulse widths; consequently a ballistic galvanometer, which is sensitive to the total charge, will respond the same way to all four pulses.

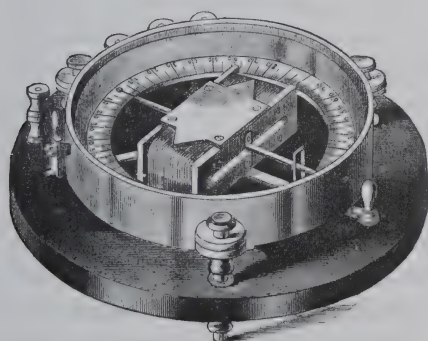


Fig. 20. The galvanometer appearing in the Loomis sketch of Fig. 2 has an appearance similar to a type a galvanometer made by J. H. Bunnell & Co. in the late 1890s for accurate nulling of Wheatstone bridges. (Lockwood, *Electrical Measurements*, 1898, p. 71)

effect of the earth's magnetic field. In place of a needle, a mirror was suspended on the thread from which an external source of light was reflected to an external scale placed about one meter away to amplify the angular motion of the mirror. Loomis did not use the Thomson galvanometer because he referred to the motion of a needle on his galvanometer more than once, and the Thomson-type of galvanometer does not have a needle.

While the Thomson galvanometer was not used, it does represent the most sensitive galvanometer of the day, and it must be assumed that the galvanometer used by Loomis was significantly less sensitive than the Thomson galvanometer. The sensitivity thresholds of galvanometers of Loomis's day were rarely published, and when they were, they generally did not specify the sensitivity thresholds to short pulses. One notable exception is the Cambridge Scientific Instrument Company of England, who manufactured galvanometers at the turn of the century. The company listed the sensitivities of several of its astatic type of galvanometers with a reflecting mirror for measuring both dc currents and the charge delivered to the coils by short unipolar pulses (see Table 5).⁴⁰ These galvanometers, designed by Professor A. Broca of Paris, were said to be even more sensitive than the early Thomson galvanometers that were used in the mid-1860s. The dc current levels shown in the table, identified as the "ampere constant," are expressed in *microamperes*, and represent the threshold dc currents that produced a 1-millimeter deflection on a light scale located at one

Table 5. Sensitivity of several Broca astatic mirror-type galvanometers available circa 1900. (F. M. Farmer, p. 22)

SENSITIVITIES OF TYPICAL BROCA GALVANOMETERS			
Resistance of galvanometer, ohms	Period, seconds	Sensitivity ¹	
		Ampere constant	Coulomb constant
8.8	10.0	2.9×10^{-3}	4.6×10^{-3}
8.8	17.3	9.3×10^{-4}	2.6×10^{-3}
110.0	10.0	1.0×10^{-3}	1.6×10^{-3}
110.0	17.3	3.3×10^{-4}	9.1×10^{-4}
860.0	10.0	4.5×10^{-4}	7.2×10^{-4}
860.0	17.3	1.5×10^{-4}	4.1×10^{-4}

¹ Ampere constant = current in microamperes which will produce 1 mm deflection at 1 meter.
Coulomb constant = quantity of electricity in microcoulombs which will produce 1 mm deflection at 1 meter.

meter from the galvanometer. The charge levels shown in the table, identified as the “charge constant,” are expressed in microcoulombs, and represent the unipolar-pulse charge thresholds that produced a deflection of 1 millimeter on the light scale at one meter. These definitions of galvanometer sensitivity were commonly accepted by the scientific community in the early 1900s.⁴¹

To show that this type of galvanometer was sensitive to short unipolar pulses produced in submarine cable telegraphy, consider a hypothetical short pulse of one millisecond with a voltage of 1 mV applied to the galvanometer listed in the table with a resistance specified as 110 ohms. The current through the galvanometer would be 10^{-3} volts divided by the galvanometer resistance of 110 ohms, or approximately 10^{-5} amps. For a pulse having a minimum pulse width of one millisecond, the charge impulse would be 10^{-8} C. The coulomb constant (threshold) for this galvanometer is 10^{-9} C, so it could easily detect the hypothetical

short pulse, which has a total charge impulse about an order of magnitude greater than the short-pulse threshold of the galvanometer.

Note that the dc resistance of the three galvanometers listed in the table increase with increasing sensitivity. For virtually all galvanometers, greater sensitivity is obtained by using more turns of finer wires or multiple coils in series, both of which cause the dc resistance of the instrument to increase. Galvanometers with high resistances would have been problematic for the Loomis apparatus because Loomis placed a galvanometer in series with the *transmit* antenna as well as the receive antenna. Any additional resistance in the transmit circuit will cause the current in the antenna to drop, which would reduce the power radiated. Even a resistance of 100 ohms will cause the current to drop in an otherwise efficient monopole or dipole radiator by more than a factor of two, and a resistance of 1000 ohms or greater will essentially quench the radiation altogether. The

cynic might say that the galvanometer did not have to be in the transmit circuit—but it was in the circuit, and that is the configuration that must be addressed. To further confirm that the galvanometer was in the transmit circuit, a second drawing by Loomis (in addition to Fig. 3) showing an experimenter attaching a kite wire to the galvanometer at the transmit station is shown in Fig. 21.

The 100-ohm Broca galvanometer shown in the table has a charge constant (sensitivity threshold) of approximately 10^{-9} coulombs. Without the mirror and external scale, the charge constant (sensitivity) would be approximately 10^{-8} coulombs. An ordinary sensitive galvanometer of the day with a resistance of no more than 100 ohms would most likely have a charge constant of 10^{-7} to 10^{-8} coulombs. A galvanometer with a charge constant (sensitivity) in this range was acquired for purposes of performing some scaling experiments. After testing a number of galvanometers, I was able to find a modern d'Arsonval meter, the Hopesun galvanometer shown in Fig. 22, that has a measured charge sensitivity of 5 to 8 times 10^{-8} coulombs.⁴²

It is interesting to note that the coulomb constants of galvanometers in the early days were measured by selecting a capacitor of known value, charging it with increasing voltage levels and discharging it across the galvanometer terminals until it responded according to the specified definition of the threshold.⁴³ The coulomb constant of the Hopesun galvanometer was measured in same

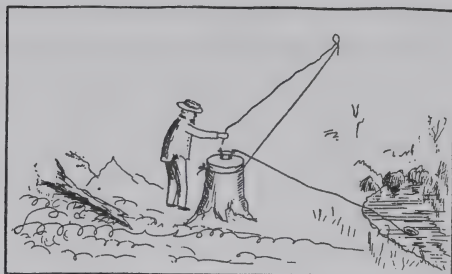


Fig. 21. This sketch by Loomis from the Library of Congress reinforces the statement in his notebook that the wire from the transmitting kite was touched to the galvanometer terminal, not directly to ground. (Library of Congress)

way by selecting a capacitor (in this case 810 pF, the capacity of the Loomis antenna), and varying the voltage applied to the capacitor before discharging it into the galvanometer. Needle motion was first observed with the 810 pF capacitor charged to 100 volts, the combination of which produced a charge on the capacitor of $CV = 8 \times 10^{-8}$ coulombs.

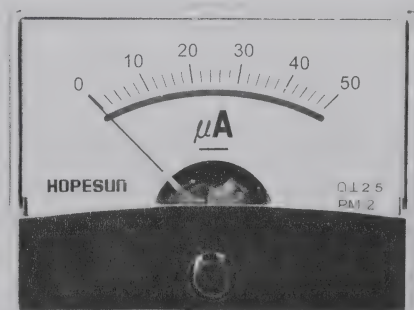


Fig. 22. This Hopesun galvanometer used in baseline tests to determine the sensitivity thresholds as a function of pulse width has a dc scale sensitivity of $1.6\mu\text{A}$, a measured dc needle movement sensitivity threshold of $0.3\mu\text{A}$, and measured ballistic pulse sensitivity of 8×10^{-8} coulombs.

Sensitivity of DC Galvanometers to Electromagnetic (Bipolar) Pulses

The sensitivity threshold of the dc galvanometer to electromagnetic pulses is considerably different from the threshold to pulses associated with marine cable telegraphy because of the difference in pulse characteristics. While the received signals for marine cable telegraphy consisted of unipolar pulses (positive for a dot and negative for a dash) with pulse widths measured in milliseconds or longer, the received signals for electromagnetic radiation are always bipolar (i.e., they oscillate about the zero baseline) and have pulse widths measured in microseconds rather than milliseconds. For example, the response of a 3-meter dipole receive antenna to radiation from a second 3-meter dipole transmit antenna excited by a spark discharge (from a Wimshurst machine) is displayed in Fig. 23, where the sensible pulse width of the response

is on the order of 200 ns. While both of these dipoles have a resonant wavelength of 6 meters, the waveform of the response would be essentially the same for two Loomis antennas, except for a difference in the time scale. The Loomis antennas were resonant at a wavelength of 732 meters rather than 6 meters, so the time scale in Fig. 23 would be expanded by a factor of 122. Thus, the period of the resonances for the Loomis antenna would be approximately 2.5 μ s per cycle, and the total pulse width, consisting of four of the largest cycles, would be on the order of 10 μ s.

It is apparent that the waveform of Fig. 23 is not only bipolar, but it appears that the average value is close to zero, if not zero—which is to say that the area under the curve above the zero baseline is about equal to the area below the baseline. In fact, it can be shown rigorously that for a linear receive antenna system (i.e., a linear load and no spark discharges in the receive antenna) exposed to a propagating electromagnetic wave, the average value of the signal delivered to the load of the receive antenna is always exactly zero (see sidebar). While the charge impulse may be zero at the end of the pulse, there are still a series of small positive and negative charge impulses during the pulse train as it decays. But if a ballistic galvanometer has not begun to respond to this type of bipolar pulse before it ends, the galvanometer will never respond.

The reason why the charge impulse is zero for the electromagnetic response of a linear antenna to an electromagnetic pulse system is easy to understand. Consider an isolated, passive, uncharged

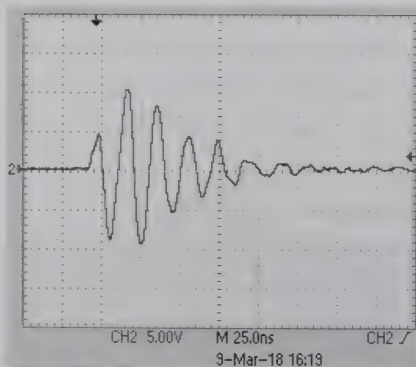


Fig. 23. Response of a 3-meter dipole antenna exposed to the radiation produced by the discharge of a Wimshurst machine without Leyden jars connected to a second 3-meter dipole at a distance of 10 meters. (Vertical scale: 5 V/div, horizontal scale: 25 ns/div.)

THE AVERAGE VALUE OF THE RESPONSE OF A LINEAR ANTENNA TO A PROPAGATING ELECTROMAGNETIC WAVE IS ZERO

The time integral of the current through a linear load $i(t)$ connected to a linear antenna excited by an electromagnetic pulse is exactly zero: $\int i(t)dt = 0$. Thus, there is no net charge impulse for a current pulse delivered to the load. This result follows directly from the fact that a dc component of the electric field cannot be radiated, so that the time integral of the electric field is zero:^a

$$\int_{-\infty}^{\infty} e(t) dt = 0$$

This is a fundamental property of propagating electromagnetic waves.

The current flowing through a linear load of a receive antenna excited by an electromagnetic pulse $e(t)$ can be characterized by the impulse response of the antenna, $h(t)$, using the convolution integral:^b

$$i(t) = \int_{-\infty}^{\infty} e(t)h(t-\tau)d\tau$$

The charge impulse for a linear load across the antenna terminals is found by integrating the current response $i(t)$ over the entire pulse. By using the fact that the time integral of the electric field is zero, it can be shown that the charge impulse, which is the time integral of the current $i(t)$ flowing through a linear load, is also zero:

$$Q = \int_{-\infty}^{\infty} i(t)dt = \int_{-\infty}^{\infty} \int_{-\infty}^{\infty} e(t)h(t-\tau)d\tau dt = 0$$

Although the average value is zero, the rms value is not, so energy can be delivered to the load despite the average value being zero. Also, it should be noted that a damped sinusoid of the form $e^{-t/2\tau} \sin \omega_0 t$, which was often used to represent the decay of propagating electromagnetic waves and the damped response of a linear receive antenna, has a non-zero integral, and therefore it does not satisfy the requirement that the average value must be zero.

^aThat the time integral of an electromagnetic wave is zero is rarely discussed in the literature. See for example, B. Di Bartolo and O. Forte, ed., *Frontiers of Optical Spectroscopy*, (Kluwer Academic Publishers, Dordrecht, Boston 2003) p. 103.

^bShane Cloude, *An Introduction to Electromagnetic Wave Propagation and Antennas*, (Taylor & Francis, London and New York, 1995) Chapter 2, p. 142; Chapter 2 contains a discussion of how antenna responses to excitation by electromagnetic radiation can be determined from the impulse response using the convolution integral.

dipole antenna with a linear load at rest. An electromagnetic pulse incident on such an antenna will cause current to flow back and forth between the two elements through the linear load, but it will not impart any net charge to the antenna. At a point in time after the pulse has passed, the antenna will return to its original equilibrium state, and the charge distribution on the dipole will be exactly the same as it was before the pulse. Consequently, there has been no *net* transfer of charge through the load to one side of the dipole or the other, so the integral of the oscillating current through the load, which is the definition of the net charge impulse, is zero. Note that the rms value is not zero, so energy has been delivered to the resistive portions of the antenna structure and load, even though the charge impulse is zero.

Unipolar and Bipolar Pulse Experiments:

In order to explore how a galvanometer responds to both unipolar and bipolar pulses, sensitivity thresholds were measured first by applying a single, positive, unipolar pulse and varying the pulse width from 10 ms to 10 μ s. The same tests were then repeated by applying a bipolar pulse (see Fig. 24) in which the positive charge pulse and negative charge pulse were equal in magnitude and exactly cancel, thereby producing a pulse with zero charge impulse.

The results of these tests on the Hopesun galvanometer for both unipolar pulses and bipolar pulses with a zero average value are plotted in Fig. 25, where the threshold voltage required to produce a galvanometer response is

shown on the vertical scale and the pulse width used is shown on the horizontal scale. The large dots represent the actual measured voltage thresholds for the selected pulse widths.

Consider first the thresholds for unipolar pulses on the left of the figure, which are expressed in terms of voltage applied to the galvanometer. The current through the galvanometer can be found by dividing the applied voltage by the resistance of the galvanometer, which is 2100 ohms for the Hopesun. The measured galvanometer voltage threshold increases in exact proportion to the decrease in pulse width so the product of applied voltage and pulse width is constant—which means the product of applied current and pulse width is

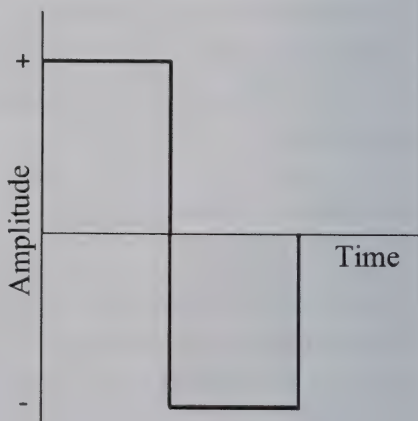


Fig. 24. The charge impulse Q is sensitive to waveform because it is proportional to the total charge flowing in one direction. For the square wave shown, here the positive charge impulse produced during the first half of the pulse is exactly cancelled by the negative charge impulse produced by the second half pulse (shaded), thereby resulting in a net impulse of zero.

also constant. As a result, the threshold of the galvanometer to unipolar current pulses can be expressed by a single number—the coulomb constant. To quantify the coulomb constant for the Hopesun, pick any voltage and corresponding pulse width on the curve of Fig. 25—say 1 volt and 10^{-4} ms. The current flowing through the galvanometer is 1 volt divided by its resistance of $2100\ \Omega$, or 0.5 ma. The charge impulse is the product of the current and pulse width, in this case 10^{-4} seconds, or 5×10^{-8} coulombs, the coulomb constant of this galvanometer, which is close to that measured by the capacitive discharge method described previously.

Now consider the bipolar pulses on the right of Fig. 25, all of which have a zero average value. The thresholds for the

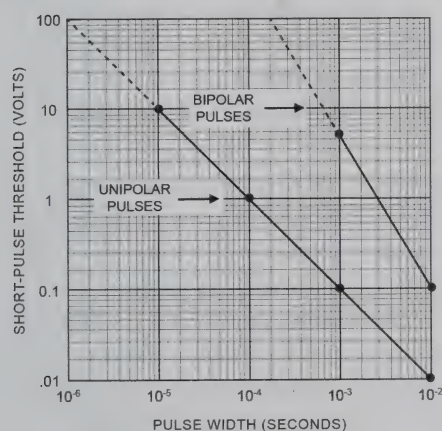


Fig. 25. Hopesun galvanometer response thresholds for bipolar pulses with a zero average value (no charge impulse) at the right of the graph, expressed in applied voltages, are much higher than for the unipolar pulses shown on the left where the charge impulse threshold is constant at 5×10^{-8} coulombs; the thresholds for the bipolar pulses increase faster than the pulse widths decrease.

bipolar responses are much larger than for the unipolar pulse, and thresholds in terms of the product of voltage and pulse width are no longer constant—the voltage thresholds are actually increasing faster than the pulse widths are decreasing. For example, for a 10 ms pulse width the bipolar threshold is ten times the unipolar threshold, but at 1 ms, the bipolar threshold is a factor of 50 more than that for the unipolar pulse. Worse yet, the extrapolated bipolar threshold for 100 μ s is 125 volts—125 times the unipolar threshold. Unfortunately, the threshold could not be measured at this level because the signal generator could not produce more than 10 volts.

It becomes obvious that a galvanometer in the ballistic mode does not respond the same way to a bipolar pulse with zero average value as it does to a unipolar pulse. The threshold in terms of applied voltage is not inversely proportional to pulse width—instead, the threshold increases much more rapidly than the decrease in pulse width. At the point where the pulse width decreases to 10 μ s, the thresholds are projected to be on order of thousands of volts.

Since the upper bound of the voltage on a Loomis receive antenna in Part II was determined to be on the order of several volts, it seems very clear that Loomis could not have detected electromagnetic waves with pulse widths on the order of tens of microseconds with any type of galvanometer that he may have used. This assertion is supported not only by the analyses and data reported here, but also the historical record that shows no one has documented the ability to receive

intelligence, much less receive a single electromagnetic pulse in the far field of a radiating antenna excited by a spark source when using a stand-alone galvanometer as a detector.

Historical Record for Using of a Galvanometer as a Detector of Electromagnetic Waves

After Hertz demonstrated transmitting electromagnetic waves and detecting them with a spark-gap loop (a nonlinear detector), the Maxwellians in England (Oliver Lodge and George FitzGerald in particular) looked for a more sensitive detector. FitzGerald studied the galvanometer in some detail and found that he could excite a galvanometer, but only using it in conjunction with the Hertz spark-gap detector by creating a very small gap in the contact between the galvanometer and the knob on the Hertz detector (see Fig. 26).⁴⁴ V. J. Phillips, in conjunction with the Institute of Electrical Engineers (IEE) in London, described FitzGerald's early radio detector—as well as virtually every other early radio wave detector that had been developed up to the vacuum tube era.⁴⁵ The FitzGerald configuration worked because a portion of the spark discharge across the knobs of the Hertz detector was diverted through the galvanometer, thereby producing a large unipolar current that caused the needle to deflect. This configuration was neither a sensitive detector nor a linear detector, since it required a spark discharge that delivered a large charge impulse to the galvanometer.

It was left to Édouard Branly to discover that a galvanometer could detect

an electromagnetic pulse at a distance of 20 meters from the galvanometer when placed in series with a battery and a coherer, which acted like a switch to place the battery across the galvanometer. Was the coherer a more sensitive device than a galvanometer? A coherer in the sensitive state is a high-impedance device (~ 1 megohm), with a very low electrode capacity (~ 1 pF), that is voltage sensitive (~ 1 volt), and switches to the low-impedance state in less than a nanosecond. While the coherer is sensitive to voltage—not an impulse of charge, per se—the voltage required to switch the coherer needed only a small amount of charge, approximately equal to $CV = 10^{-12}$ farads $\times 1$ volt = 10^{-12} coulombs. Compare that to the charge impulse threshold for the most sensitive type of reflecting galvanometer in Table 2, which requires greater than 10^{-10} coulombs to respond.

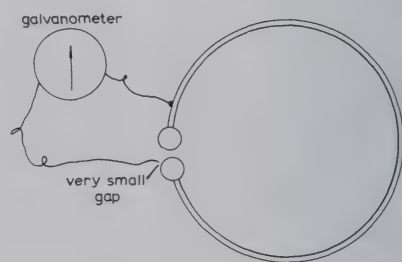


Fig. 26. Professor George FitzGerald found that he could not excite a galvanometer with an electromagnetic pulse unless he used it in conjunction with the Hertz spark-gap detector by creating a very small gap in the lead between the galvanometer and the knob on the Hertz detector to allow a portion of the spark discharge to flow through the galvanometer. (Phillips, *Early Wave Detectors*, p. 16)

As a final point, Thomas Appleby wrote that Robert Marriott, a founder and the first president of the Institute of Radio Engineers, claimed in an article appearing in *Radio Broadcast* of December 1925 that the Loomis arrangement worked for him [Marriott] many times. What Marriott actually wrote was this:

“Stating the Loomis claim briefly and in present day language: if you put up an antenna where it will get atmospheric charges, and interrupt the flow of current from antenna to ground, you can send messages. If the atmospheric voltage is high enough so that the sparks from antenna to ground will jump a gap of one inch, it would be possible to send messages more than a hundred miles to a *present day receiver*. However, the atmospheric voltage is not reliable for telegraphing, because conditions vary widely in different locations and at different times.”⁴⁶

Note that Marriot said “*a present day receiver*,” [emphasis added], which in 1925 meant a vacuum tube detector in a regenerative or superheterodyne receiver plus amplifier stages—not a galvanometer. Also Marriott stated that the gap must be one inch, which translates to a voltage of 75 kV, not the upper bound of 18 kV for the Loomis antenna. Also, Marriott was aware that the electrical environment of the atmosphere was unreliable, but it appears that he was unaware the charging time required for the Loomis antenna to reach a voltage that produced a spark across a gap of a quarter of an inch was somewhere between 5 to 40 minutes.

Summary and Conclusions

Summary

The analytical techniques and experimental data presented in this paper represent a fresh approach to the question whether or not the Loomis wireless telegraphy system powered by electricity from the earth’s atmosphere was capable of communicating intelligence by means of electromagnetic radiation (radiotelegraphy) to a distance on the order of 20 miles. The major findings of the study are summarized first, followed by several unequivocal conclusions.

The Charging Time of the Loomis Antenna is Far Too Long to Support Radio Telegraphy.

1. Using the accepted model of the electricity in the earth-ionosphere cavity, supplemented by experimental data, the shortest charging time of Loomis’s antenna to reach 67% of the upper bound to the antenna voltage was found to require a minimum of five minutes.
2. Using five minutes as the shortest charging time for the Loomis antenna, the upper bound to the transmitted pulse repetition rate is one pulse every five minutes, which corresponds an upper bound to the word rate of about four *hours* per word, or about six words per day. This calculation is based on the standard word of Morse code, PARIS, which requires 50 dot-equivalent spaces for dots, dashes, and spaces. This calculation also assumes that

a dot can be represented by a single discharge from the Loomis antenna, and a dash can be represent by three discharges. The nominal minimum accepted word rate for wireless telegraphy in the day was between 10 and 20 words a minute.

3. Such a low word rate would not be practical for communicating intelligence. There does not appear to be any combination of parameter values in the Loomis system (such as increasing the height of the kite, the size of the conducting electrode on the kite, or the wire diameter of the antenna) that would materially increase the speed of transmitting of intelligence. There would have been no support by private investors, public corporations, or governments for developing or using such a system.

Sensitive Galvanometers Are Insensitive to Antenna Responses Produced by Propagating Electromagnetic Radiation.

1. Sensitive dc galvanometers of the day were capable of measuring short current pulses by sensing the charge impulse through the galvanometer. The response of these instruments by the ballistic excitation method is proportional to the total charge flowing through the galvanometer (i.e., the time integral of the current). Consequently, galvanometers are more sensitive to unipolar pulses rather than to bipolar pulses produced in

receive antennas, whcih have zero average value.

2. Using the fact that the time integral of the propagating electric field is zero, it can be shown that the response of a linear system exposed to electromagnetic radiation, such as an antenna with a linear load, has a zero net charge impulse (the time integral of the current flowing through a galvanometer in an antenna circuit is zero). Even the most sensitive galvanometers with astatic magnets and reflecting mirrors, similar to the Thomson type, could not detect a short-pulse unipolar signal with zero average value unless the applied voltage was far in excess of hundreds if not thousands of volts.

Loomis Could Not Have Received an Electromagnetic Signal at a Distance of 20 Miles in the Blue Ridge Mountains.

1. An upper bound analysis using the familiar Reiss equation for calculating the transmission and reception of propagating electromagnetic fields in ideal lossless antennas, including monopole and dipole antennas, through a lossless atmosphere results in a maximum voltage of a few volts across a galvanometer with a resistance matched to the load.
2. Loomis claimed he used an ordinary dc galvanometer of the day without benefit of some type of nonlinear device. No galvanometer of the day,

without benefit of a nonlinear device, had the sensitivity to detect a single electromagnetic pulse in a dipole or monopole receive antenna exposed to radiation in the far field of a radiating antenna excited by a spark source.

3. While the upper bound to the voltage on the antenna was 18 kV, the actual voltage would have been less than 4 kV for four reasons:

- The maximum altitude of the kite in a wind would have been reduced by at least 3 kV because of the angle of the kite in the sky relative to a vertical line normal to the transmitter location on the earth's surface.
- Based on experimental data, the maximum voltage on a vertical antenna with a patch at the altitude of the kite is estimated to be no more than one half of the maximum voltage of the earth's equipotential surface at the top of the antenna.
- Loomis was very clear that he repeated his experiment three times, separated by five minutes. [*After a lapse of five minutes, as previously arranged, the same performance was repeated until the third time.*] The antenna potential would have recovered to at most 50% of its maximum value in five minutes.
- The radiated energy would have been further reduced because Loomis placed a galvanometer in the transmit circuit that would have further reduced the current in the antenna—thus reducing the voltage appearing across the radiating portion of the

monopole antenna to less than the reductions of the previous three factors, which amount to a reduction to 4 kV.

4. No one has documented receiving a single electromagnetic pulse in the far field of an antenna excited by a single spark source using a galvanometer as the detector without benefit of some type of nonlinear device.

Conclusion

It is clear that Loomis did not envision a method of communication by radiating electromagnetic radiation because he described a closed-loop circuit in which conduction through the earth is an important component. It is well known that electromagnetic radiation is a one-way trip, and return currents from the receiver to the transmitter that travel through the earth are not necessary. Having said that, it is not necessary that an inventor understand how his mechanical or electrical invention works; in this case, it is only necessary that, within the bounds of the physical configuration described in his patent and supporting documentation, it does, in fact, work.

Based on all the evidence presented here, one must conclude that Loomis could not have communicated intelligence to any distance using electricity extracted from the atmosphere because of the long charging time between pulses, which results in data rates of a few to perhaps ten words per day—so low that no individual company,

Did Mahlon Loomis Really Invent Radio?

government entity, or military branch would have any economic or practical use for a communication system based on extracting energy from the atmosphere. It is also clear that Loomis could not have sent and received even a single electromagnetic signal to a distance of 20 miles, as he claimed, because he did not use a nonlinear detection device, and there is no known galvanometer of the day that could have received his ten-microsecond-long electromagnetic signal impulses without the aid of such a nonlinear device—not even the astatic, reflecting mirror galvanometer of the Thomson type.

Was Loomis a charlatan, a crackpot, or a sincere but deceived wireless pioneer? Perhaps Loomis was able to send signals to shorter distances using electrostatic induction methods such as the quintessential method tested by Thomas Edison in 1887? Perhaps he was able to send and receive signals at much shorter distances? Perhaps he never tried to send actual messages, just signals? None of these options are consistent with the following observation he made during his test in the Blue Ridge Mountains, which he documented in his notes:

“At the opposite station [receiver] the ground wire being already fast to the galvanometer, three separate and deliberate half-minute connections were made with the kite wire and the instrument [at the transmitter]. This deflected, or moved the needle at the other station with the same vigor and precision as if it had been attached to an ordinary battery.”

No wireless technique, whether it be electromagnetic radiation or electric-field induction, will move the needle of a galvanometer for 30 seconds as if it were connected to a battery. The only possible explanation for that observation is that he was measuring the steady-state current collected by the kite patch and wire from the atmospheric electricity—not from his “transmitting antenna.” Whether or not his galvanometer could have measured such a low dc current is problematic.

In summary, it is clear he did not describe or envision a method of communicating intelligence in his patent or other known writings that is consistent with using electromagnetic radiation. All of his descriptions speak of disturbing the natural environment that caused return currents to flow between the transmitter and receiver through the ground. There is no known written record of the results of his experiments by an independent observer or observers. There is no evidence anyone has reproduced Loomis’s stated results or demonstrated a method of wireless telegraphy to communicate intelligence to long distances using only energy or power extracted from the atmosphere. There is no evidence that anyone has received propagating electromagnetic signals produced by spark discharges in the far field of an antenna with a stand-alone galvanometer.

It truly can be said that Mahlon Loomis did not discover a method of communicating intelligence to long distances by extracting energy from the earth’s atmosphere. But he will surely remain a footnote in the history of electronic communication for a number of firsts: first

to receive a patent for aerial telegraphy, first to use a kite as an antenna, first to use monopole antennas with grounded electrodes in both the receiver and transmitter circuit, first to describe a system to operate on energy extracted from the atmosphere, and first to propose a worldwide system of aerial telegraphy.

Author's Note: The finding that the Loomis system did not work is not surprising because the absence of a nonlinear detector has always been the Achilles' heel of his method. However, one could argue that Loomis's patent was really for the concept of a wireless system powered by extracting energy from the atmosphere, which was not restricted to a particular type of detector. After all, he clearly stated in his patent that he did not devise a new detector, and he did not even specify a galvanometer in his patent,⁴⁷ meaning that he could have used any available detector—arguably, even one invented in the future. What is surprising is that the real Achilles' heel of the Loomis system as described in his patent turns out to be the long antenna charging time required between discharges, which makes communication of intelligence by extracting energy from the atmosphere impossible. What is also surprising is that radio historians who have studied the Loomis system have apparently been oblivious to what has been known by the atmospheric electricity community for many decades, namely that it takes a very long time for a conductor to reach its equilibrium potential with respect to earth when placed in the atmosphere in the vicinity of the earth's surface.

Endnotes

1. See for example *Webster's New World Dictionary* (Houghton Mifflin Harcourt, New York 5th ed., 2016) p. 1198. All competent definitions of radio that have appeared since the term was generally adopted in 1906 include two concepts—the transmission of intelligence, or communication (as opposed to merely signaling), and the use of electromagnetic waves. The distinction between communication and signaling has to do with data rates. When Branly discovered electromagnetic waves triggered his "radiodetector" (coherer), he was able to detect a *signal* but he could not communicate intelligence with his apparatus.
2. Waymarking Images, <https://s3.amazonaws.com/lgs-waymarking-images/737bb215-423d-40e2-a508-5796844194b4.jpg>; this particular sign marker appears across from 232 Park Street in West Springfield, MA, where he lived before moving to Washington, D.C., in 1856. This sign states that the two Loomis stations in the Blue Ridge Mountains were 14 miles apart, but in his writings and newspaper accounts of the day, the distance is clearly stated as either 18 to 20 miles or 20 miles. The distance of 14 miles is based on a sketch drawn by Loomis stating that the two sites were Bear's Den and Catocin Mountain, both being a spur of Blue Ridge Mountains of Virginia. It is generally believed that the peak of the Catocin Mountain in Virginia is Furnace Mountain, which is located at a distance of 19.3 miles from Bear's Den.
3. The beginning of the far-field region for antennas and sources of interest to this paper is defined as a distance equal to one to two wavelengths of energy or power radiated by the antenna. For monopole antennas excited by wide-band spark sources, the most significant radiated wavelengths are centered on the primary antenna resonant wavelength, which is approximately four times the antenna height.
4. Thomas Appleby, *Mahlon Loomis, Inventor of Radio*, (Loomis Publications, Washington, DC, 1967); unfortunately this rare document containing some critical design parameters is out of print. Some of the important information regarding Loomis's general approach appears in the next reference, which is available on the Internet.
5. This author did not personally examine the documents from the Library of Congress from

- which Appleby quoted. The basic parameters used in the analysis were confirmed by other reliable documents, and the fundamental conclusions reached in this effort do not depend critically on the content of Appleby's citations.
6. S. R. Winters, "The Story of Mahlon Loomis, Pioneer of Radio," *Radio News*, Vol. 4, No. 5, Nov. 1922, pp. 836–837, 966–978, 980, 982: <http://www.americanradiohistory.com/Archive-Radio-News/20s/Radio-News-1922-11-R.pdf>.
7. *Ibid.*, p. 836.
8. Appleby, p. 9.
9. K. L. Aplin and R. G. Harrison, "Lord Kelvin's Atmospheric Electricity Measurements," *Hist. Geo- and Space-Sci.*, Vol. 4, 2013, pp. 83–95; <https://arxiv.org/ftp/arxiv/papers/1305/1305.5347.pdf>.
10. Appleby, *Mahlon Loomis*, p. 78; Loomis's entire lecture delivered to the Franklin Institute in 1881 is reproduced in this reference on pages 77 to 85.
11. Appleby, p. 40; Appleby reproduced this image courtesy of the Library of Congress.
12. Mahlon Loomis Papers, 1854–1910, Library of Congress, Manuscript Division. <http://invention.si.edu/mahlon-loomis-papers-1854-1910>
13. Shortly after Loomis filed a patent on his method, *Frank Leslie's Weekly* magazine of April 26, 1873, reported the following about Mahlon Loomis: "He claims to have thoroughly tested his discovery by telegraphing between two mountains in Virginia twenty miles apart."
14. Mahlon Loomis Papers at the Library of Congress; reproduced in Appleby, pp. 14–16.
15. There would be no spark when the connection was broken—as in telegraphy with a spark coil—because the voltage of the antenna would be essentially zero after a one-half minute connection to ground.
16. "Wireless via Kites," *Washington Evening Star*, April 30, 1909; these are the same parameter values that Appleby used in his calculations of the resonant frequency.
17. Appleby, p. 29.
18. *The Earth's Electrical Environment*, (National Academy Press, Washington, D.C., 1896) p. 211; <http://www.everythingselectric.com/product/earths-electrical-environment/>.
19. Gaetan Chavalier, "The Earth's Electrical Surface Potential," January 2007, http://162.214.7.219/~earthio0/wp-content/uploads/2016/11/Chevalier_electrical_surface_potential-2007.pdf; L. L. Williams, "Electrical Properties of the Fair-Weather Atmosphere and the Possibility of Observable Discharge on Moving Objects, Jan. 1999, <http://www.konfluence.org/efield.pdf>; Online edition of *Feynman Lectures on Physics, Vol. II*, Chapter 9, "Electricity in the Atmosphere," 2013, http://www.feynmanlectures.caltech.edu/II_09.html.
20. This figure is adapted from one prepared by Colin Price, "The Global Atmospheric Electric Circuit," Tel Aviv University. See, <http://www.tau.ac.il/~colin/courses/AtmosElec/Global%20Circuit2013.pdf>.
21. Lighting discharges would produce noise that would dominate the signals radiated from antennas.
22. "The Earth's Electrical Environment," p. 211.
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27. J. A. Fleming, *The Principles of Electric Wave Telegraphy and Telephony*, (Longmans Green & Co., New York, 1910, 2nd ed.) p. 842.
28. S. Ramo, J. Whinnery, and T. Van Duzer, *Fields and Waves in Communication Electronics*, (John Wiley & Sons, New York, 1965) p. 718.
29. For example, the rate of charge collected by a wire with a diameter of 1 mm and a length of 183 meters (area of 0.18 meters) by an impinging current density of 2 pA/m² is 0.4 coulombs per second. The rate is just about doubled when for the patch on the kite that has an area of 0.16 m². At that rate, it would take about 10⁷ seconds (many days) for the antenna wire and patch to accumulate 8.2 × 10⁻⁶ coulombs—the charge required to produce a voltage on the antenna with respect to ground of 18 kV.
30. J. Alan Chalmers, *Atmospheric Electricity*, (Pergamon Press Ltd., London, New York, 1967) p. 40, 123.
31. *Ibid.*

32. A. J. Bennett and R. G. Harrison, "In Situ Calibration of Atmospheric Air Conductivity Instruments," *Review of Scientific Instruments*, Vol. 77, 2006. R. G. Harrison, "An Antenna Electrometer System for Atmospheric Electrical Measurements," *Review of Scientific Instruments*, Vol. 68, 1977, p. 1599–1603.
33. Lars Wåhlin, *Atmospheric Electrostatics*, (Wiley & Sons, New York, 1989), Chapter 6, Instrumentation and Measurements; www.colutron.com/download_files/chap6.pdf.
34. Note that many manufacturers use the notation $T\Omega$, meaning teraohm or $10^{12} \Omega$, for their impedance specifications. The only suitable commercially available electrometer found with an input impedance spec of greater than $10^{15} \Omega$ was a pricy Keithley Model 6430 that has an input impedance spec of $>10^4 T\Omega$ ($>10^{16} \Omega$). All other Keithley electrometers, including the Model 6512, have a minimum input impedance spec of $200 T\Omega$, as do most other manufacturers.
35. A. J. Bennett and R. G. Harrison, *Advances in Geosciences*, pp. 11–15. The authors of this paper claim that an input resistance of $\sim 10^{15} \Omega$ must be considered a minimum requirement, and they say they used a Keithley 6512 electrometer with "an input specified of greater than $2 \times 10^{15} \Omega$." However the Keithley 6512 spec sheet clearly states it has input impedance of $>200 T\Omega$, which is an order of magnitude less $>2 \times 10^{15} \Omega$. (One $T\Omega = 10^{12} \Omega$.)
36. Bennett and Harrison, ADGEO, p. 14.
37. The 40 by 40 cm conducting patch on the kite with two exposed surfaces has a total surface area of 0.28 m^2 , while the 1 mm antenna wire extending from the kite to the ground has a surface area of $\pi dl = 3.14 \times 0.001 \times 183 = 0.57 \text{ m}^2$.
38. Frank Malcolm Farmer, *Electrical Measurements in Practice*, (McGraw-Hill, New York, 1917) p. 26.
39. The response will diminish when the pulse width gets so short that the high frequency content in the pulse causes the inductive impedance of the coil to approach or exceed its dc resistance, thus reducing the current through the coil(s). At even higher frequencies, the parasitic capacity will cause the current to flow around the coils, essentially shorting them out. These frequency-limiting effects are not likely to occur at frequencies at or below those of interest to the Loomis antenna, which is resonant at 410 kHz.
40. Farmer, table: "Sensitivities of Typical Broca galvanometers," p. 22.
41. Farmer, p. 12–13.
42. The Hopesun galvanometer sensitivity was measured by several different techniques that produced slightly different results.
43. G. D. Aspinall Parr, *Practical electrical Testing in Physics and electrical Engineering*, (Longmans Green & Co. London, 1901) Section 82, "Calibration of a Ballistic Galvanometer (Standard Condenser Method)" p. 139–140.
44. G. F. FitzGerald, *Nature*, Vol. 42, 1980, p. 173.
45. Vivian J. Phillips, *Early Radio Wave Detectors*, (IEE, London, 1980) p. 16.
46. Robert Marriott, "How Radio grew Up," *Radio Broadcast*, Vol. 8, No. 2, Dec. 1925, p. 162.
47. Loomis patent states, "I do not claim any new key-board nor any new alphabet or signals; I do not claim any new register or recording instrument;" but . . . What I claim is . . . The utilization of natural electricity from elevated points . . ."

Acknowledgements

I would like to thank Dr. Kendall Casey of Sequim, WA, for discussions on the energy content and frequency distribution of energy in spark sources and the dependence of the quantity of spark energy radiated from a monopole and dipole as a function of antenna length. I would also like to thank Bryan Long for drawing a number of figures that appear in this paper. He can be reached through his website at www.sethdesignstudio.com for freelance work.

About the Author

Eric P. Wenaas has had a lifelong passion for antique radios beginning with his first Radiola and crystal set given to him as a young man growing up in Chicago by family friends. He experimented with radio devices and repaired radios and televisions as a hobby while in high school, and went on to study electrical engineering at Purdue University, graduating with B.S. and M.S.

Did Mahlon Loomis Really Invent Radio?

degrees in Electrical Engineering. He then went to the State University of New York (SUNY) at Buffalo where he earned a Ph.D. degree in Interdisciplinary Studies in the School of Engineering. After graduating, he spent most of his career at Jaycor, a defense company in Southern California—first as an engineer and later as the President and Chief Executive Officer.

Upon his retirement in 2002, he set out to research the early days of wireless and document interesting historical vignettes based on original documents of the era. He has assembled an extensive collection of Radiolas from the 1920s and wrote an award-winning book on the subject. He has also assembled a large collection of French and American crystal sets, and he is now gathering original document collections of well-known

inventors and historians that recorded the history of the wireless and early broadcast era. He has recently become interested in repeating experiments of early wireless pioneers to compare what they could have observed with what they said they observed.



Eric Wenaas

History of Voice of America Audio Processing

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The Voice of America (VOA) used various technologies in international shortwave (high frequency or HF), double-sideband, AM broadcasting to improve intelligibility and maximize reception. Advances included progressively higher transmitter power, improved transmitting antennas, propagation software, and increasingly complex audio processing. Some of the HF stations provided a signal that was clear and easy to understand while others did not, even though they may have had similar received signal strengths. The history of analog audio processing used at the Voice of America is recounted here with a short comparison to Radio Free Europe/Radio Liberty. A unique digital system that was designed and tested for the VOA, but never incorporated, is described. Commercial digital processing units that were actually deployed are also described. As many stations used similar techniques, this work can largely be considered a history of shortwave broadcast transmission processing, which uncovers some details that have been buried for decades and not brought to light until now.

Introduction

Germany used shortwave radio to effectively disseminate news and propaganda both before and during World War II. The United States was late in the race to use shortwave at the beginning of the war, but began in earnest immediately after Pearl Harbor. After the war, shortwave broadcasting grew and became a popular medium of communication. During the Cold War, Russia competed with the United States for shortwave radio coverage. Each country grew their transmitter count, power level, and total hours transmitted. In 1950 the VOA transmitted 497 hours per week as Radio Moscow delivered 533 hours. By 1990 the VOA was airing 2,611 hours

per week, while “Radio Moscow,” now renamed the “Voice of Russia,” transmitted 1,875 hours.¹ Receiver sensitivity and selectivity improved, but congestion and jamming also increased, making reception quite difficult at times and often requiring high listener skill. The Voice of America found itself in a continual loop of competition to be heard and to effect diplomacy around the globe. Systems were devised to overcome jamming and to provide an increasingly louder and more reliable signal to the listener. Among these techniques was transmission audio processing.

The VOA initially led the development of their own audio designs and later took advantage of commercial

audio processing improvements. This author has yet to discover audio processing used for HF transmission before the late 1940s, but after WWII, simple tube-based audio clipping and filtering were incorporated to help cut through the noise. In the 1970s, solid-state equipment became the norm. Transistors and integrated circuits allowed for more complex circuitry in a smaller unit. Improved

limiting techniques and multiband processing proliferated in the 1980s. Today, digital signal processing (DSP) is mature and provides even louder audio with few artifacts. During these advances in audio performance, the U.S. government, and later, commercial manufacturers, devised novel techniques and testing methods to achieve increased intelligibility of international broadcasting.

PART 1. A SHORT TECHNICAL HISTORY OF THE VOA

Before the American government formed its broadcasting unit, six private commercial U.S.-based shortwave outlets existed.² At the beginning of World War II, the U.S. government leased these outlets because the United States did not yet have its own studios and transmission systems. Existing transmitter sites such as WLWO in Cincinnati, KGEI, WRUL, W2XE (CBS), General Electric (KGEL, WGEA, WGEO), Westinghouse, Associated Broadcasters, Worldwide Broadcasting Foundation, and the WCAU Broadcasting Company were corralled to broadcast government information during the war, using power levels up to 50 kW, usually into rhombic antennas. KWID in San Francisco, operated by Associated Broadcasters, was one such station (Fig. 1).³ The government also sent programming to the BBC for broadcast to Europe from its UK-based transmitters.⁴

Consolidation

The United States organized a service

to broadcast information to foreign countries shortly before entering World War II:

“In mid-1941, President Roosevelt established the U.S. Foreign Information Service (FIS) and named speechwriter [Robert] Sherwood as its first director. Driven by his belief in the power of ideas and the need to communicate America’s views abroad, Sherwood rented space for his headquarters in New York City, recruited a staff of journalists and began producing material for broadcast to Europe by the privately-owned American shortwave stations. Sherwood also spoke with officials in London about the prospect of relaying FIS material over the facilities of the British Broadcasting Corporation (BBC).”⁵

The Coordinator of Information (COI) and Office of War Information (OWI) were created. With studios in New York City, programs were recorded

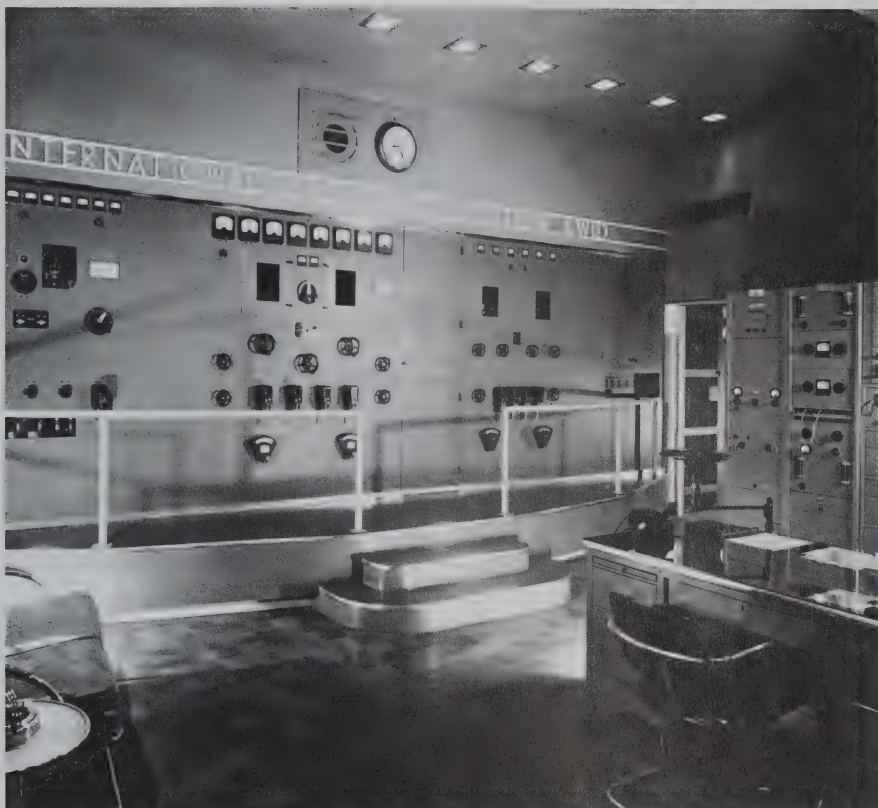


Fig. 1. A General Electric transmitter at KWID near San Francisco was leased by the government and operated by the Office of War Information (OWI) in World War II before the VOA was formed. (<http://www.theradiohistorian.org/wcsw/wcsw.h58.jpg>)

and broadcast to Europe to combat the German propaganda effort (see Fig. 2).⁶ As the United States entered the war in response to the Japanese Pearl Harbor attack on December 7, 1941, the U.S. foreign broadcasting efforts crystallized.⁷ While the OWI leased the commercial transmitters, 23 new transmitters were built under contract with the government.⁸ The VOA Dixon Ohio site and the Delano, California, site shown in Fig. 3 were built in 1944 to help cover the Pacific theater of the war.⁹

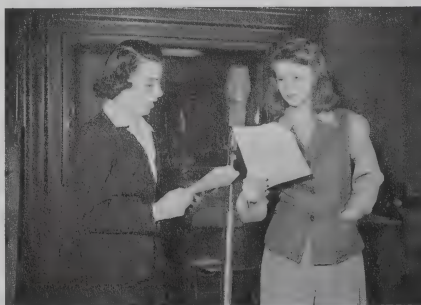


Fig. 2. The American message broadcast during WWII to combat German propaganda was, "You can't do business with Hitler." (Library of Congress)



Fig. 3. The VOA Delano transmitter control room in the early 1950s. A bank of Langevin 1-C clippers appear in the background. (Radio World.com)

Expansion

After the war, the U.S. shortwave voice was placed under the Department of State and was reorganized as the *Voice of America* in 1945. Communist jamming of VOA transmissions began in February of 1948,¹⁰ and the next year a transmission modernization program called “The Ring Plan” was announced to increase coverage and signal strength.¹¹ Designed by MIT, new feeder links, relay stations, and power levels of 250 kW and 500 kW, with 1 MW medium wave transmitters, were proposed to “ring” the Soviet Union with U.S. programming. Continental Electronics Corp. founder and super power advocate, J. O. Weldon, was a key person in the 1 MW AM transmitter plan. The ring plan also included a transmitter on the U.S. Coast Guard Cutter *Courier*.¹²

Communist Trouble

In 1953, the U.S. shortwave voice was placed under the newly created U.S. Information Agency (USIA).¹³ The Office of Engineering and Technical Operations then managed VOA engineering.¹⁴ The newly expanded broadcasts to Russia used the new relay stations and sometimes necessitated paths over difficult northern auroral zones, as Radio Moscow upped their radio effort in response.¹⁵ This was the beginning of the radio “Cold War,” and radio Moscow also expanded broadcasts to Korea at the beginning of the Korean conflict.¹⁶ That same year, Senator Joe McCarthy initiated hearings with charges that the VOA was filled with Communists. Because of the hearings, the West Coast transmitter site plans were halted,¹⁷ but the Greenville site was built.¹⁸

Retired VOA engineer Sheldon Daitch adds that a North Carolina site was scuttled, causing a move to Greenville, and a Washington state site was cancelled, thus trimming the Ring Plan a bit:

“I don’t think it [the Ring Plan] was totally stopped. Erching Long Wave site was built in either the late 1940s or early 1950s. Also the Medium Wave and HF sites at Poro Point, Philippines and Okinawa were also early 1950s. Kavala, Greece was later, but the old Rhodes, Greece site was also maybe early 1950s. Also, the old Tangier facility, about the same time. No doubt that the North Carolina consolidated facility, which eventually became Greenville, which was slated for the early 1950s (Baker East) and the proposed

station near Seattle (Baker West) were casualties of Joe McCarthy.”¹⁹

After being delayed by the McCarthy hearings, USIA engineer Howard Delong (see Fig. 4), along with Smith-Meeker Engineering, completed new studios and a network control center in Washington, D. C., to consolidate operations in 1955. Gates Radio built the audio distribution equipment,²⁰ and the project centralized news, production studios, and program distribution (Fig. 5).²¹

Better Radios and Stronger Signals

In the 1950s, shortwave popularity increased as higher quality radios started incorporating tighter intermediate frequency (IF) bandwidths using either critically tuned ferrite-based IF transformers or narrow Collins mechanical filters. Inexpensive portable solid-state receivers became available in the 1960s. In the mid-1970s, when more stations went on the air, inexpensive ceramic filters created tight IF filtering, often narrower than previously found in consumer radios. While sharper IF band passes and audio filtering were used to attenuate noise and adjacent channel interference, some of the desired intelligibility was lost.

As new transmitters and antennas were commissioned, propagation software such as VOACAP,²² IONCAP, SKYCAP, and others enabled the optimization of transmitter antenna directions and patterns. They also optimized time and frequency of signal delivery to target areas for specified signal-to-noise ratios and reliability. Part of this process was automated in the 1980s.²³



Fig. 4. VOA Chief Engineer Howard Delong in 1955. (Gates Studio Review, Aug. 1955, p. 2)



Fig. 5. The Gates-built VOA control center in Washington, D. C., allowed consolidated program delivery to the various transmitter sites around the world. (<https://www.voacambodia.com/a/175368.html>)

In 1984, the VOA initiated a research program to improve coverage and increase the quality of service to all target areas using shortwave broadcast bands between 6 and 21 MHz. Rhombic antennas continued to be superseded by dipole curtain arrays (Fig. 6), which offered higher gain and in some cases adjustable beam direction. Curtain arrays with six stacks were recommended for 52% of the areas, while 4-stack arrays were best for 44%, and a 2-stack curtain array for the last area. Beam steering optimization was achieved by changing the vertical and horizontal phase of the elements in a curtain array.²⁴

Glasnost and The Web

The beginnings of Glasnost, or increased governmental and civilian openness in Russia in 1985, led to the relaxation of radio competition. Here, Radio Moscow was renamed “the Voice of Russia,” and severely curtailed operations. After the Cold War ended around 1991, the VOA, BBC and other stations reduced their broadcast hours and, at times, power. Many stations eventually left the air.

In 1994 the VOA created an Internet presence and started streaming audio over the Web. Around 2008, HF transmitting stations started closing as the Internet permeated the world. Sheldon adds:

“Briech, the new Morocco station, shut down in maybe March 2008. I was there. I thought I had a copy of the OPMEMO, operations memo with the shutdown time, but I can’t find it. Bethany closed much earlier, then Delano and Dixon, I don’t have dates and don’t know the date when Greenville Site A was shut down.”²⁵

In 2014, budget cuts resulted in the closing of half of the Greenville, North Carolina facility. Local FM, digital media distribution via Internet streaming, and satellite became the core avenues for VOA distribution.²⁶ During the life of the VOA, increased audio processing for HF had improved reception.

PART 2. SIGNAL PROCESSING BASICS AND EARLY DEVELOPMENTS

The goal of audio signal processing for broadcasting is to provide a reliable audio signal for the listener and at the same time to prevent transmitter over-modulation and adjacent channel interference. For AM (and shortwave) radio, the louder the audio, the farther a signal is heard. One quarter of an AM transmitter’s peak power is in each sideband (for a total of half the peak power), while the other half of the total power is in the carrier. The audio information is carried in these sidebands, which have a limited peak level. So for AM transmissions, the peak-to-average ratio must be reduced to make the most of the signal. Audio pre-emphasis is also used to provide a reciprocal of an average receiver’s high frequency response. These techniques increase intelligibility. To control occupied bandwidth, a low pass filter is added to the transmitter system.

Increasing audio density is achieved by broadcast processing. If there is more rms power in the sidebands, the receiver will demodulate a louder audio signal, thereby overcoming noise in the

channel.²⁷ Measurement of loudness can be subjective or objective. For testing purposes, objective results are most often presented in a peak-to-rms ratio in dB; the lower this ratio, the louder the signal. For subjective tests, listener panels are polled. Various audio processing techniques are used to increase the intelligibility. These include volume compression, equalization, peak limiting, clipping, and filtering.

With the help of universities, engineering firms, and manufacturing companies, the VOA achieved goals for their transmissions to have minimum specified signal strength and received signal to interference ratios for transmissions usually via ionospheric skywave propagation at 90% reliability.²⁸

Issues in HF Broadcasting

Hindrances to successful shortwave delivery involve propagation variances (solar cycles, sunspots, and maximum useable frequencies), short-term and long-term fading, envelope detector distortion, man-made and atmospheric

noise, and finally interference (both unintentional and jamming). Delivering shortwave programming utilized skywave propagation paths in a narrow radio channel of 10 kHz, which resulted in a relatively narrow 4.5 kHz audio passband.²⁹ These issues, along with receiver limitations, form a very challenging delivery system.

Receivers

Issues with older receivers involved local oscillator drift, poor selectivity, poor sensitivity, and image products that caused reception of unwanted signals. Receiver AGC (automatic gain control) tended to exacerbate the envelope detector distortion during a signal fade. Newer radios often suffer from poor image rejection due to low intermediate frequencies and wideband front ends that allow for overload.

Jamming

During the cold war, the Soviet Bloc jammed many U.S. transmissions, starting with 200 jamming transmitters in 1948 and increasing to about 1,700 by 1988. This forced the VOA to increase power levels up to 500 kW and improve antenna systems.³⁰ Audio processing improvements also helped overcome this jamming.

Loudness Research

Bell Labs pioneered speech research as they developed the U. S. telephone network. In 1929, Leon J. Sivian studied speech power for the Bell System.³¹ This study found that perceived loudness is based on the human ear's response to

aural stimulation, and in 1933, a pioneering report published by Harvey Fletcher and Wilden Munson of Bell Labs defined loudness and described the ear's response based on frequency and sound pressure level.³² The *Fletcher-Munson* curve remains the basis of all loudness measurement today. A variant is used today for movie and television dialog level setting.³³ The updated ISO standard *Normal Equal Loudness Level Contours 226:2003* is the current standard.³⁴ This research defined the average power level of the average voice as well as its frequency spectra.

In the War Years, Joe Licklider (Fig. 7), with a fresh Ph.D. in psychoacoustics, studied speech intelligibility in communications systems at Harvard's Psycho-Acoustic Laboratory. He discovered that peak clipping did not generally reduce intelligibility because the speech information was located primarily in the zero crossings of the waveform. Licklider published a paper describing his work in the *Journal of the Acoustical Society of America* in 1946.³⁵ In this paper he noted that a clipped voice signal was more intelligible than a non-clipped signal in a radio circuit. From his extensive testing, he came to this conclusion:

"If a communication system has insufficient amplitude-handling capability to pass the peaks of speech and at the same time to provide an adequate intensity level, maximal intelligibility is obtained by clipping off the peaks and using the available power for the remainder of the wave."³⁶



Fig. 6. This dipole curtain array at the VOA Greenville, North Carolina, transmitting station has a higher gain than earlier rhombic antennas, making it capable of beaming to directed targets such as Cuba and South America; this newer style HR 4/2/1 wideband curtain array has two rows of four dipoles high and can have a gain up to 19.7 dBi. Some sites may also have some rhombics and dipoles. (Photo by Macon Dail)



Fig. 7. Joe Licklider discovered that peak clipping did not generally reduce intelligibility because the speech information was located primarily in the zero crossings of the waveform. (Ekla web Blog, <http://everyman.eklablog.com/j-c-r-or-lick-a118540178>)

Joe determined that 12–15 dB of audio clipping in a radio circuit was about optimum. This work guided some amateur radio clippers as well as commercial clippers of the day. With this research, Mr. Licklider and his colleagues improved cockpit voice communications during WWII. Joe later became a visionary in interactive computing who foresaw worldwide shared computing. He helped start Lincoln Labs and passed away in 1990.³⁷

In extremely simplified form, the ear is most sensitive to the mid-frequencies, matching the frequency range of the human voice. The louder the signal, the easier it is to hear through noise. HF audio processing takes advantage of this psychoacoustic phenomenon by accentuating these frequencies, and clipping is often used.

The First AM Limiters

I have yet to find evidence of commercial broadcast compressors, limiters or clippers existing in America before 1937, but the earliest developments are interesting. A number of AM broadcast station engineers built their own limiters or compressors before commercial units became available. For instance, Robert J. Rockwell of Crosley's WLW-AM claims to have built the first "automatic amplifier" in 1935.³⁸ This limiter-expander amplifier received a patent in 1941.³⁹

Western Electric 110A Program Amplifier

The very first commercial limiter appears to be the Western Electric 110A Program Amplifier (Fig. 8),⁴⁰ announced at the May 1937 IRE convention, which hosted



Fig. 8. The Western Electric 110A Program Amplifier is believed to be the very first commercial AM broadcast transmission limiter, although home-brew broadcast limiters existed as early as 1935. (Image from WE 110A flyer)

a paper about the unit called "*Higher Program Level without Circuit Overloading*" by O.M. Hovgaard and S. Doba.⁴¹ In 1938 a version of this paper that fully described the WE 110A was published in the January 1938 issue of *Bell Laboratories Record*.⁴² A product announcement in the June 1937 issue of *Radio Engineering* magazine noted that the 110A increased a station's coverage, but did not create a tight limit ceiling because only 3 dB of limiting was recommended; however, this 3 dB gain effectively doubled a station's reach. This not-so-tight ceiling limitation would be resolved decades later. The article forecast the day of fully automatic level control that released the broadcast console operator from riding levels (now true), but no evidence exists that the 110A was used for shortwave.⁴³

The 110A was 19¼" high in a rack, had input and output controls, a VU meter, and peak flasher with level set. Inside was a variable-loss network using varistors that increased loss as the signal was limited. Tubes were a 6J5 input amplifier, 6C5 rectifiers, and a 6F6 output amplifier—all single ended. The 110A weighed 68 pounds and drew less than 100 watts power.

Close Behind

Later in 1937, the RCA 96A Limiting Amplifier was developed with NBC and installed in all NBC stations for domestic

AM broadcast service. The same year, Gates announced the 17-B audio compressor. Thus began the field of audio processing.

All but the WE 110A tube-based limiting or compression amplifiers operated in a balanced push-pull mode to prevent the gain control voltage from modulating the audio path. These early AM broadcast limiters did not incorporate pre-emphasis, clipping, or filtering that was later incorporated, and I have not discovered any HF station using audio clipping or limiting before 1937.

PART 3. VOA ANALOG PROCESSING OVER THE YEARS

The Voice of America's shortwave services through the decades used essentially five analog processing devices for its transmissions:

1. The Langevin 1-C Clipping Amplifier
2. The Gates Level Devil model CS-1960 Audio Level Governing Amplifier
3. The Kahn Symmetra-Peak phase scrambler
4. The UREI 1A Audio Peak Limiting Amplifier
5. The Orban Optimod-HF 9105A processor

In addition to analog devices used by the VOA, the CRL MBL-100 AM Modulation and Bandwidth Limiter that Radio Free Europe and Radio Liberty (RFE/RL) used will also be discussed as it is germane

to the shortwave audio art. Digital signal processing devices evaluated and used by the VOA are addressed in Part 4, "Enter Digital Signal Processing (DSP)."

The Langevin 1-C Clipping Amplifier

In my view, the Langevin 1-C clipping amplifier (Fig. 9) was the beginning of HF audio processing because this was the first unit specifically designed to maximize shortwave broadcast modulation and coverage. It incorporated multiple techniques in one box to increase intelligibility and cut through jamming. This author has not determined the actual date of introduction, but the Langevin 1-C clipper, which was designed by the Department of State (VOA) and built by Langevin Corporation, was put in service before September of 1949 and was used into the 1970s.⁴⁴



Fig. 9. The Langevin 1-C Peak Clipping Amplifier, also known as the State Department Clipper, was designed for the U. S. Information Agency (i.e. VOA) to combat Russian jamming; it was the first audio filter and clipper specifically designed for shortwave transmission. (*Electronics*, Sept. 1949, p. 83)

Herrick Fights Jamming

VOA Chief Engineer George Q. Herrick spearheaded the project while State Department international broadcast engineers under the guidance of VOA Engineer Julius Ross performed the engineering design. This “State Department clipper” was a successful response to Soviet jamming that started after World War II. VOA engineer Howard Delong recalled:

“When jamming started, George Herrick came up with the idea of using a “clipper” on the VOA transmitters. The clipper is a device that chops off the highest peaks in the sound as it’s being transmitted through the transmitters, and effectively raises the average volume or loudness of the transmission. In addition to that, it provided for

pre-emphasis, on the theory that the sibilant sounds add more to the intelligibility of the received signal than just an ordinary flat characteristic. So we pre-emphasized the higher tones in speech, and the “s’s” and such sounds as that. Julie Ross did the development work on the clipper, and I had to write an instruction book for the overseas transmitters. These devices were used on the transmissions and effectively increased the loudness of VOA signals all during the jamming period, and we continued to use them right up until around 1977 or thereabouts.”⁴⁵

Did the RCA PLEX Start It All?

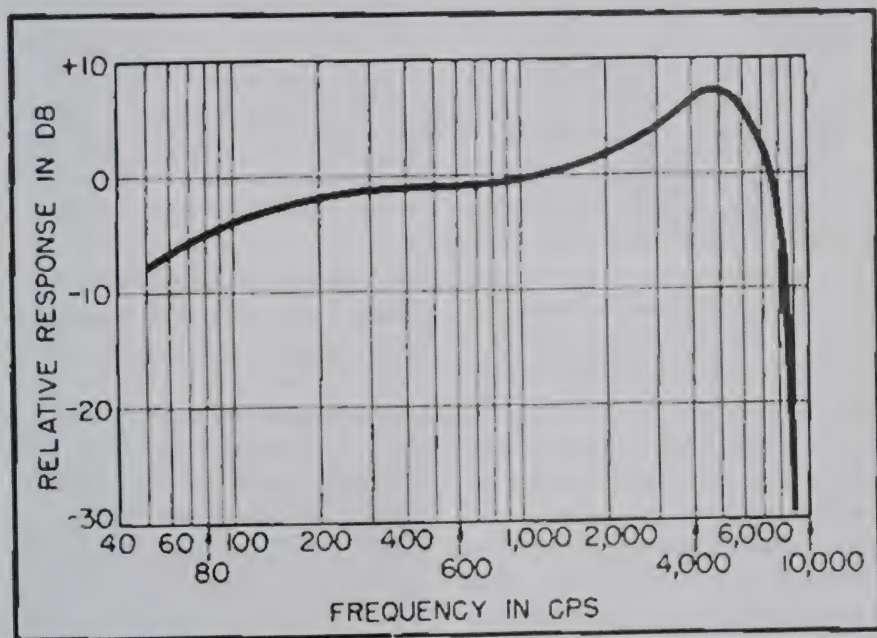
The Langevin 1-C clipper was probably based on the 1947 RCA PLEX (Peak Limiter and EXpander) communications

speech limiter.⁴⁶ This clipping amplifier was designed for two-way AM transmission to prevent overmodulation in crowded radio channels. It gated background noise, increased talk power by up to five times, and filtered harmonic distortion with a low-pass filter to limit bandwidth.

Langevin 1-C Details

The State Department Clipper used the same clipping and low-pass filtering

techniques as the PLEX, but did not use an expander. The Langevin unit reduced low-frequency vowel sounds, emphasized the mid-range, sharply filtered unwanted highs to limit bandwidth, and clipped peaks to allow for maximum modulation. A second gentler low-pass filter then reduced clipping distortion and adjacent channel interference. No compression or soft limiting was used. The consonant sounds were emphasized through the shaped response curve shown in Fig. 10,



**Gain characteristic of the amplifier.
At 1,000 cycles for 50 db the noise
is 67 db below a milliwatt.**

Fig. 10. The frequency response of the "State Department" clipper was boosted in the mid- and high-frequency range for consonant and sibilant sounds, thus increasing intelligibility for short-wave. Derivations of this response are used to this day for shortwave broadcast transmission. (Electronics, Sept. 1949, p. 86)

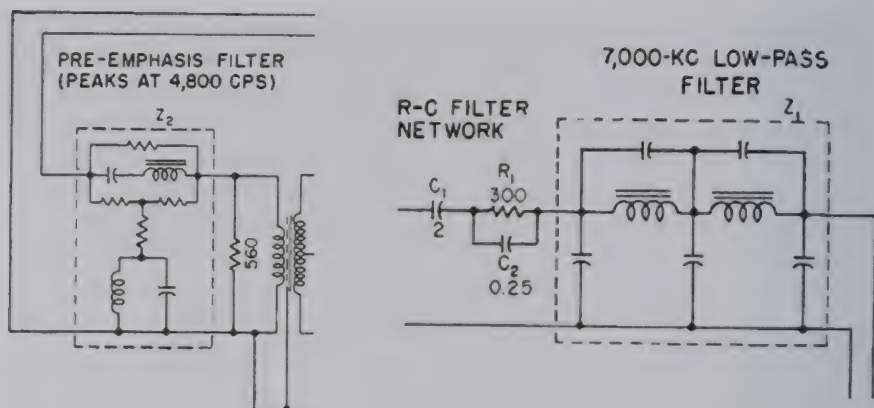


Fig. 11. The frequency response of the Langevin 1-C was determined by these two filters, which are connected by clipping level selector pushbuttons. More modern processors replaced the inductors with ICs and resistors. (Electronics, Sept, 1949, p 82)

which was derived from two separate equalization circuits shown in Fig. 11 that are separated by clipping control pushbuttons. I believe this is the first use of this basic speech-enhancing response curve for HF, which became commonplace for shortwave transmission processing. With the clipping that followed, a very loud signal was created. Clipping and frequency shaping made this unit unique.

Controls and Tubes

The controls for the Langevin 1-C consisted of input and output level attenuators with scales, clipping level pushbuttons with test mode, a multi-function meter switch, and a power switch. Included was a VU/test meter and power indicator. The front door was designed to swing down for easy parts replacement. The unit used 6SJ7 sharp cutoff pentodes as amplifiers and clipping diodes, with a pair of 6V6 beam power tetrodes in push-pull for the output stage.

An OD3 voltage regulator tube regulated the high-voltage supply to the clipper plates and screens, while a 5Y3 or 5U4G rectifier supplied high voltage DC.

State Department Clippers Were Loud

George Herrick was not interested in audio automatic gain control or limiting for transmission because he felt it would not create the loudest speech. He believed that speech clipping was simply louder than either limiting, or limiting followed by clipping. The Langevin unit was controversial because the clipping caused severe harmonic distortion, often rendering music unintelligible; however the advantages of the 1-C's processing structure substantially increased the audibility of voice on shortwave to cut through jamming.⁴⁷ The 1963 Langevin catalog claimed that with the increased intelligibility and higher modulation, almost four times the signal loudness was obtained as compared to no processing.⁴⁸ After a notable career as a

broadcast engineer, Mr. Herrick passed away in 1977.

Transmitters Were Strained

While the State Department Clipper pictured in Fig. 12 was used at all VOA sites, the louder audio from the clipper strained the VOA transmitters. Modulator system design goals for the General Electric 250 kW transmitters installed in Greenville required 50% more modulator power than non-clipped signals used in domestic AM broadcasting.⁴⁹ Also, a special modulation transformer was built, and the modulator stage had low-frequency audio compensation to allow a very low frequency response of a few cycles to pass the clipper's square waves faithfully and retain maximum loudness.

The 1-C clipper was advertised commercially as late as 1962 in the Langevin catalog, but it was no longer in their 1967 catalog after the company had adopted solid-state technology. Langevin did

not advertise any replacement to their clipper, and the VOA replaced the 1-C clipper with solid-state UREI 1As in the 1970s. The 1-C shown in Fig. 13 was listed in their 1963 price sheet at \$1,425 (about \$11,487 today) and weighed 60 pounds. No known examples of the Langevin 1-C exist today, and the author has yet to find a manual for this unit. If anyone has further information, I would appreciate hearing from you.

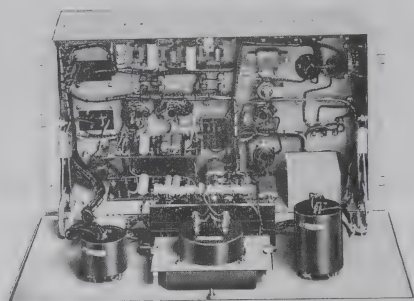


Fig. 13. The Langevin 1-C Clipping Amplifier with a door that opened for easy component troubleshooting and replacement. (Langevin Catalog 1963, p. 23, courtesy of John Klett)

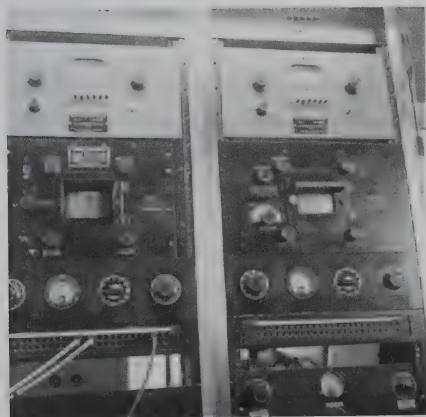


Fig. 12. The Langevin 1-C clippers "in action" as seen in early VOA racks probably dates from the 1940s. (Courtesy Dave Snyder, VOA Museum)

The Gates Level Devil Model CS-1960 Audio Governing Amplifier

The commercial Gates Level Devil audio level-governing amplifier shown in Fig. 14 that was popular in AM radio stations was later modified in 1960 at the request of the State Department to correct the audio levels of the various VOA HF relay feeds. The Level Devil was an automatic gain control amplifier and expander that controlled levels up to 30 dB with a slow averaging compressor along with an expander to reduce noise of the source. This device did not augment loudness nor feed a transmitter directly.

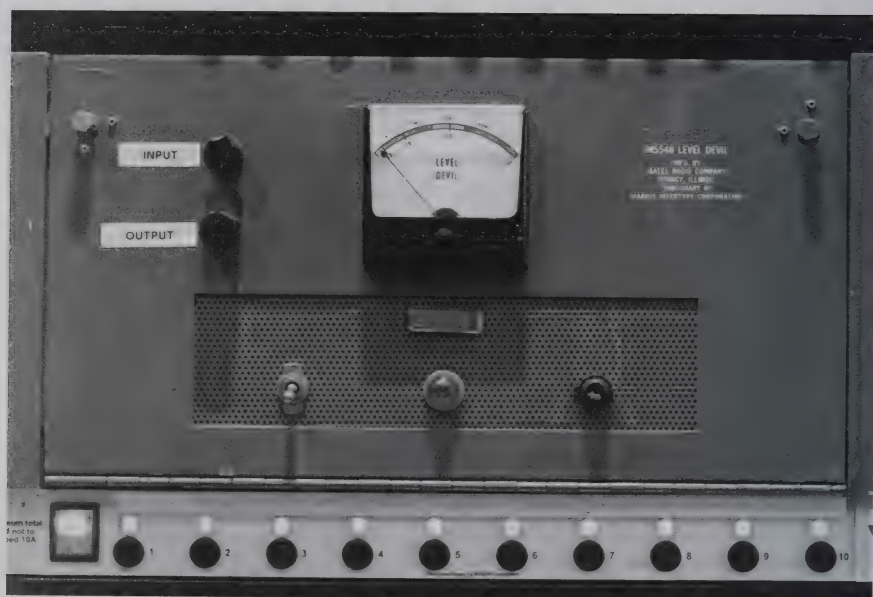


Fig. 14. The Gates Level Devil leveling amplifier controlled levels for AM broadcast stations. A custom version for the VOA handled noisy incoming HF feeds over a 30 dB range. (Rick Wrigley blog website)

Level Devil Uniqueness

The modified CS-1960 State Department version of the Level Devil took its control signal from the input as compared to the output as in the standard Level Devil. This change enabled expansion with noisy HF relay sources to help make the feeds less noisy. Sheldon noted:

“In those old days, programs came to the HF sites overseas by two means, the HF relay from domestic transmitters and for the non-timely programming, either transcriptions in the early days then later magnetic tapes. The live programming, news especially, was carried via the HF transmitters from the States, then supplemented with the commercial satellite circuits.”⁵⁰

Level Devil Controls and Tube Issues

The front panel consisted of a power switch, indicator light, fuse, and gain reduction meter. The controls behind the front panel and on the chassis were an input stepped attenuator, output tee attenuator, limiter and expander enable switches, a function selector switch, meter zero, and tube balance potentiometers. The Level Devil used a matched pair of 5749 (6BA6W) remote cutoff pentode tubes in push-pull as gain control elements. Burn-in, balancing, and careful tube selection for the gain control circuit were needed to avoid DC shift. Gates suggested separate tube burn-in and balancing test rigs for tube aging and selection. After burning in for more than 48 hours, tubes were matched, and

the selected set of tubes were installed and rebalanced using the front meter.

The Level Devil's audio path was fully balanced and contained miniature tubes, primarily 12AX7, 12AU7, and 12AT7 dual triodes. Much of the circuitry was on a printed circuit board, a technique that became popular in the 1950s. The Gates Level Devil contained 13 tubes in a 10.5-inch high rack unit and drew 60 watts of power.⁵¹

The Kahn Symmetra-Peak Phase Scrambler

The Kahn Research Laboratories Symmetra-Peak SP 58-1A phase scrambler shown in Fig. 15 was used at VOA transmitter sites, often preceding a limiter such as a UREI 1A. This passive unit introduced around 1959 used an L/C all-pass lattice network that equalized the phase of the human voice (which is

most often highly non-symmetrical) to make the audio waveform symmetrical, which is illustrated in Fig. 16. The voice before the all-pass lattice network is asymmetrical (the positive peaks are much higher than the negative peaks) while the voice after the network is symmetrical (the positive and negative peaks are approximately equal). The symmetrical signal could be more effectively processed, since the program limiter that followed worked on an even waveform. If the signal was not symmetrical, the limiting would not be as loud as possible. This network allowed an increased loudness of voice by up to 4 dB without excessive limiting.⁵² Phase scramblers were later made from operational amplifiers and capacitors in the 1980s, and today, digital signal processing based phase rotators are used in all broadcast processors.

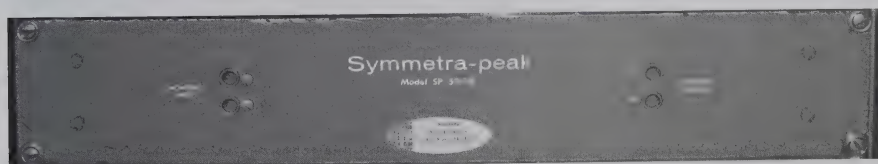


Fig. 15. The VOA used the Kahn Symmetra-Peak phase scrambler to gain loudness of voice programming in the 1960s, as did many AM radio stations. (<http://www.theonlineengineer.org/TheOLEBLOG/symmetra-peak/>)

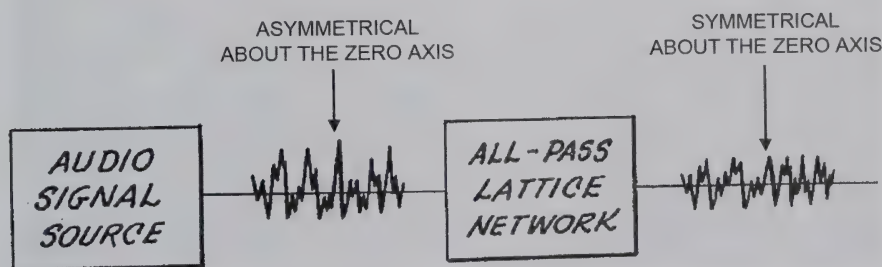


Fig. 16. Voice waveforms were made symmetric by the Kahn Symmetra-Peak system, resulting in greater loudness without distortion after limiting. (U.S. Patent 3,060,389)

Audio processing designer Bob Orban adds:

“Phase scramblers, being linear filters, are about the closest thing you get to a ‘free lunch’ in audio processing. It’s likely that Kahn discovered this by accident as a side effect of the 90 degree phase difference networks he used for his envelope elimination and restoration SSB transmission technique, which allowed high-powered SSB transmitters to be more efficient.”⁵³

The passive Symmetra-Peak had no controls, did not require power, and was used at many domestic AM stations in the 1960s to make the stations louder. Leonard Kahn received a patent (one of about 100) for his phase scrambler and later created a version of stereo AM. He

was a brilliant engineer, passionate about AM radio, and aggressively defended his ideas. Kahn passed away in 2012.

The UREI 1A Audio Peak Limiting Amplifier

United Audio, later known as United Recording Electronics Industries (UREI), introduced their model 1176 recording limiter in 1967. This was the first discrete transistor solid-state limiter that became a very popular limiter in recording studios due to its smooth sound (there are also do-it-yourself clones and commercial copies currently available). UREI owner Bill Putnam, shown at work in Fig. 17, also owned many recording studios and manufactured recording consoles and other gear such as recording compressors, limiters, and equalizers. Mr. Putnam was known



Fig. 17. UREI founder Bill Putnam, known as the “inventor of modern recording” is conducting a recording session for Frank Sinatra at his Western Recorders studio. (Pro Sound Europe, Nov. 7, 2016)

as the father of modern recording and recorded many major artists such as Frank Sinatra and Bing Crosby. Mr. Putnam passed away in 1989, but his son Bill Jr. still runs UREI.

Use of a FET Transistor

The popular UREI 1A 1176 used a field-effect transistor (FET) as a variable resistor in a voltage divider circuit to control gain (Fig. 18). FETs as gain control elements were new in the late 1960s, simple and effective. Many firms used a derivation of this basic FET gain control circuits for both audio and RF circuits until improved voltage-controlled amplifier ICs arrived in the 1970s.

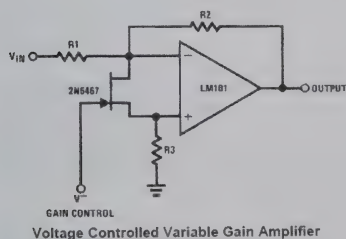


Fig. 18. Used in The UREI 1A, a small signal FET transistor acted as a variable resistor depending on the gate voltage applied; it was simple and effective, and replaced older variable mu tubes. Later VCA ICs were developed. (Fairchild Semiconductor Application Note AN6604)

Modification of the UREI 1A 1176

At the request of the U.S. Information Agency in 1976, UREI adapted their 1176 limiter for shortwave transmission and called it the Model 1A Audio Peak Limiting Amplifier (Fig. 19). Recording equipment restorer David Kukla noted:

“All AM and shortwave stations need high-quality limiters, and the VOA was no exception. Due to interference from other stations, jamming from unfriendly governments, noise from lightning and power lines, and numerous other problems, these stations have at most around 20 dB of dynamic range. At lower levels audio is buried in background noise, and if levels are too high the transmitter will over-modulate, causing distortion and possible damage. To prevent overload and maintain good intelligibility and punch through the background noise, good limiting is essential.”⁵⁴

Similarities

Like the Langevin 1-C before it, the UREI 1A increased modulation density, prevented overmodulation and restricted bandwidth, but without the high amounts of distortion that the older

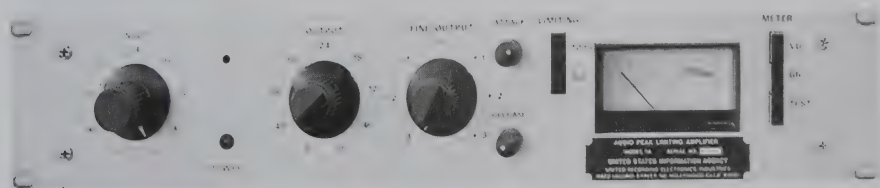


Fig. 19. The UREI 1A Audio Peak Limiting Amplifier replaced the Langevin 1-C clipper at the VOA transmitter sites. This model is very rare today because recording technicians remove the frequency selective parts and the clipper to turn it into a model 1176 recording limiter. (UREI website <https://www.uaudio.com/blog/claude-origins-urei-1a/>)

State Department Clipper created. It was not as effective as the older tube clipper in cutting through jamming, but sounded smoother. The UREI 1A used a similar frequency response curve as the older 1-C as it included input pre-emphasis, an input low pass filter, a fast limiter, a 5 kHz output low pass filter, and a line clipper. Bill Putnam set the compression ratio at 20:1 for a tight limit ceiling, and used fast attack and release times. This fast limiting increased the modulation power of voice by about 2.5 dB over a normal release time constant.⁵⁵ Peaks that could cause overmodulation were clamped by a diode bridge at the output.

Description

Controls consisted of an input level potentiometer along with coarse and fine output level controls. A limiting switch selected 0 dB or 10 dB of limiting. A VU meter indicated input level, gain reduction or a test position that inserted a 10 dB pad so that high-level tones could be measured. The UREI 1A was two rack units high, weighed 11 pounds, and drew less than 15 watts. List price is unknown, but the 1176 limiter was \$489 in 1973, and retails for \$2,000 today.

The VOA used the 1A until circa 1988 (Fig. 20) when the Orban 9105A was introduced. Information on the

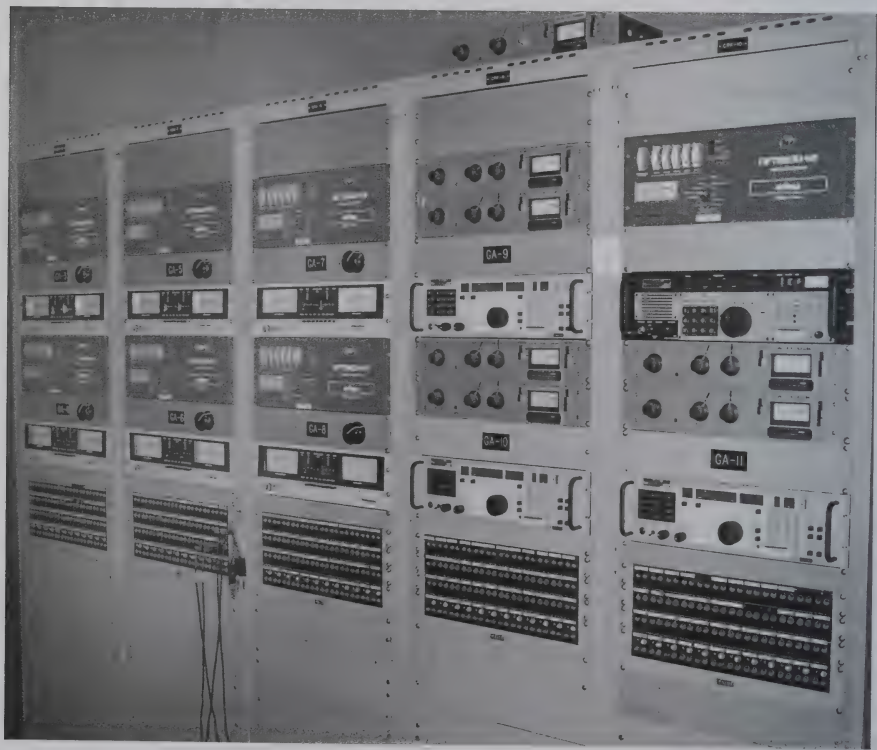


Fig. 20. UREI 1A limiters (and Optomod 9105A's as well as monitoring receivers) in use at the VOA transmitting station in Greenville, NC, around 1995. (Courtesy Jim Hawkins)

Internet indicates that when a UREI 1-A sells on the used market, the special circuitry for shortwave is most often removed to re-create an 1176 recording limiter for studio use. There are not many UREI 1As around today and none in use.

The Orban Optimod-HF 9105A Processor

Introduced at the 1988 convention of the National Association of Broadcasters (NAB),⁵⁶ the Orban Optimod-HF 9105A audio processor shown in Fig. 21 was the most complex and effective analog shortwave broadcast processor that advanced the state of the art for many years. The term *processor* was then coined to denote a single unit that performed multiple functions.

Evolution from Domestic AM Processing

The 9105A maximized loudness by frequency shaping similar to previous devices but added new techniques that increased the audio level in novel ways. It listed for \$5,850 in the 1997 Harris broadcast catalog (equivalent to \$9,197

today) and was designed using a complete shortwave systems approach. The Optimod-HF was adapted from Orban's domestic 9100A AM processor. Multiband compression and limiting first used in the 1970s on domestic AM created higher density. Judicious clipping from the 9100A was used to good effect, and new clipping was added to the Optimod-HF.

Many Processing Modules

Like many broadcast processors of the 1970s and 1980s, the Optimod-HF 9105A used operational amplifier ICs along with voltage-controlled amplifiers. The 9105A incorporated a band-pass filter, a phase scrambler, receiver and bass equalizers, AGC, multiband limiting with clipping, a new Hilbert Transform clipper, overshoot compensation and a low-pass filter. User adjustments allowed settings for normal and poor propagation scenarios. For the first time in HF broadcasting, the 9105A added controls to correct for transmitter tilt and antenna HF compensation that corrected for transmission system

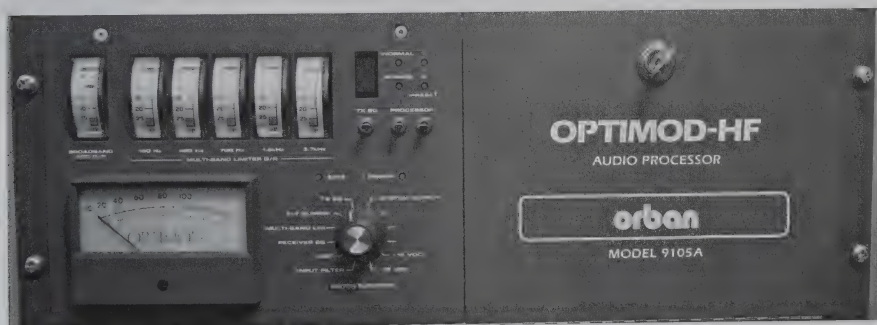


Fig. 21. The Orban Optimod-HF 9105A processor with meters on the left and a locked door on the right hiding the controls. Protection of these controls behind a locked door started in domestic broadcast processing to prevent DJs from changing the sound of radio stations, as some tried. (Author's collection)

distortions.⁵⁷ Each section helped to add to loudness and intelligibility. Also for the first time, presets could be selected remotely.⁵⁸ By the mid-1990s, a majority of HF stations used the 9105A, and the VOA was a complete adopter.

Panel Description

The front panel had six vertical gain reduction meters, a large test VU meter with a selector switch, and toggle switches for both transmitter equalization and processing presets (see Fig. 22). Behind a locked door were controls for density, equalization, clipping, and transmitter equalization (see Fig. 23) These settings were usually not changed often. One of

two presets could be recalled via remote control when propagation conditions warranted.

Systems Approach To Design

In a paper published in the *Journal of Audio Engineering Society* describing the Optimod-HF, Mr. Orban noted that traditional testing to achieve simply the lowest peak to average ratio was no longer enough, and that distortion was better judged psycho-acoustically rather than using a traditional distortion meter (i.e., to create more loudness, he allowed for more distortion than in domestic processing). So Bob Orban designed the 9105A by modifying his successful model

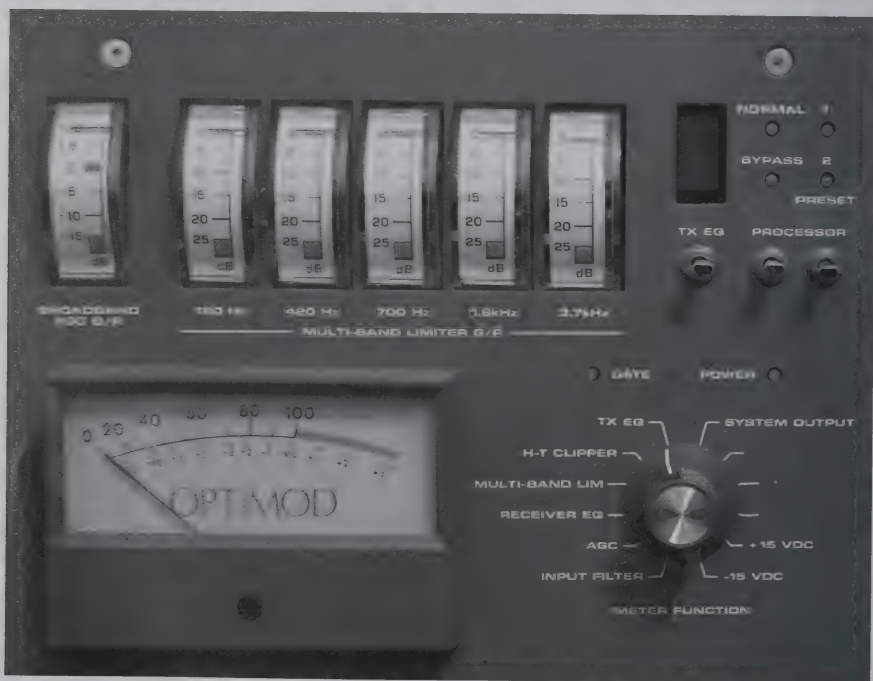


Fig. 22. The Optimod-HF 9105A meters included one for broadband gain reduction, five for audio bands from 150Hz through 3.7KHz, and a test meter with selector switch for troubleshooting. (Author's collection)

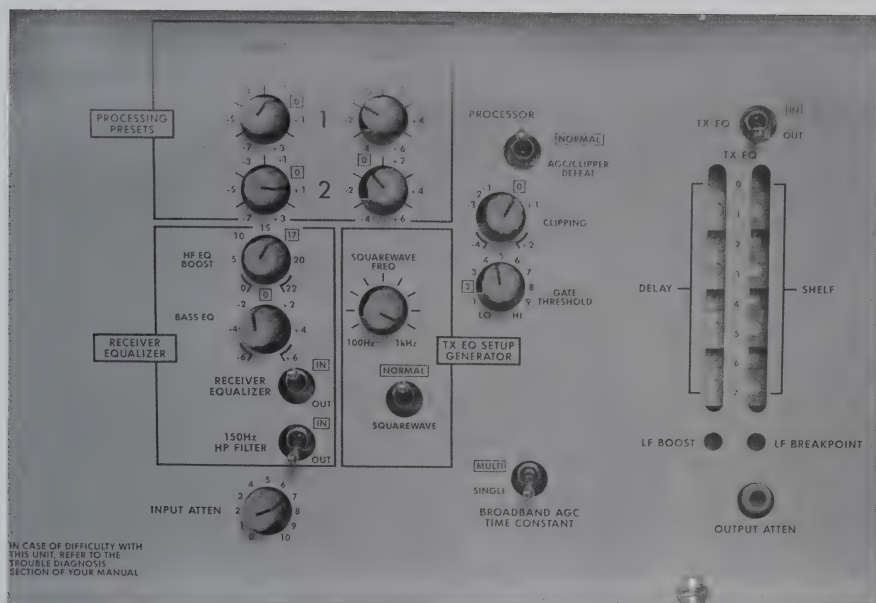


Fig. 23. The controls that were hidden behind the locked door on the right of the Optimod 9105A panel are shown here. These controls defined how aggressive the sound could be made, and they allowed for receiver audio and transmitter distortion corrections. (Authors collection)

9100A domestic AM processor by changing limiting, equalization, clipping, and filtering to maximize intelligibility for a narrow shortwave channel. For this goal, Orban studied receivers, transmitters, and shortwave propagation together as a system to create his new processor.

Bob described how he developed the processor:

“I developed the 9105A in a fairly casual way. It started with the recognition that speech was more important in international HF than it was in domestic medium wave (MW) at the time, and that HF listeners were often motivated to listen when reception conditions probably would have driven away domestic MW listeners.”⁵⁹

Narrow IF Filters Muffle Audio

In the author’s view, the inexpensive, steep IF ceramic filters that became popular in consumer receivers of the 1970s and 1980s were a main cause of narrow and muffled audio. The Sony ICF2010 and ICF2002 receivers Orban tested had ceramic IF filters (the 2010 having a 4 kHz narrow filter for only 2 kHz of audio). To help bring out the voice range, Bob sculpted the dynamic frequency response:

“Also changed in the 9105A as compared to the domestic 9100A were the thresholds of the various bands of limiting. Here the new box had a lower bass limiter threshold to restrict the bass response (with an added

switchable 150 Hz HPF). The mid-range clipping threshold was reduced to allow more audible midrange to be pushed through.”⁶⁰

Receiver Characterization

In designing the Optimod-HF, Bob Orban measured the frequency response of three consumer portable shortwave receivers, averaged their relatively narrow frequency curves (see Fig. 24 for one example), and added noise to an RF test source to gauge effectiveness of his modifications to a 9100A domestic AM processor. As these shortwave radios had a narrow frequency response, Orban used to good advantage his newly designed complementary receiver equalizer (Fig. 25) that he had made for the 9100A.⁶¹ To improve intelligibility, this

equalizer handily pre-corrected for the steep IF roll-off of the shortwave radios.⁶² Bob explains:

“I bought two Sonys and a Grundig. All were consumer-oriented battery-operated radios. IIRC, one of the Sonys and the Grundig had switchable IF bandwidth. The Sony were not cheap. There was one very small one, which I no longer have (I don’t recall the model #, although I probably have it somewhere in my files), and an ICF-2010, which I still have and which is a very nice piece that sells on eBay for over \$200 today.

“The ‘narrow’ mode on some radios offers lower audio bandwidth than a toll-quality POTS telephone connection,⁶³ so I was trying to ensure that

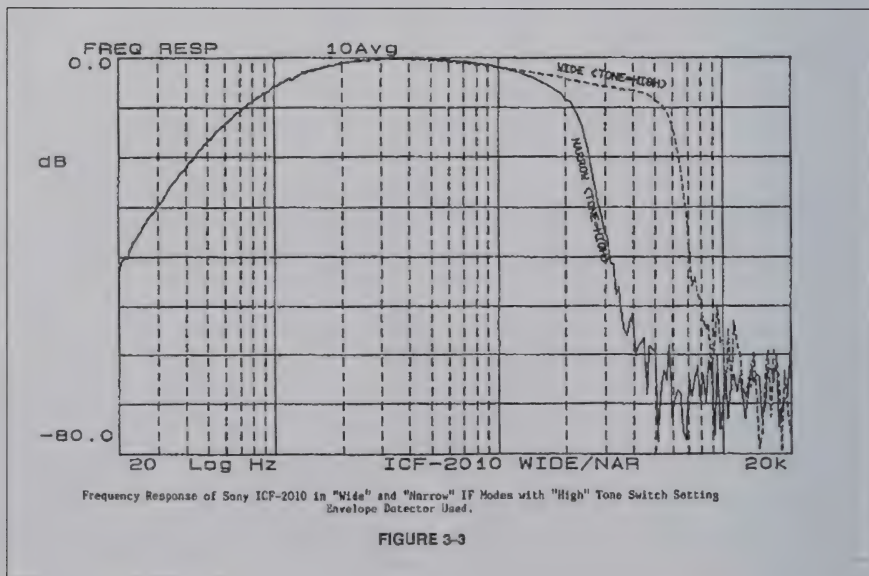


Fig. 24. Frequency response of a Sony ICF2010 shortwave receiver showing wide and narrow IF selections. Many modern portable shortwave receivers have similar response curves, and Bob Orban designed the Optimod-HF around the narrow curve. (AES preprint 2789, March 7-11 1989)

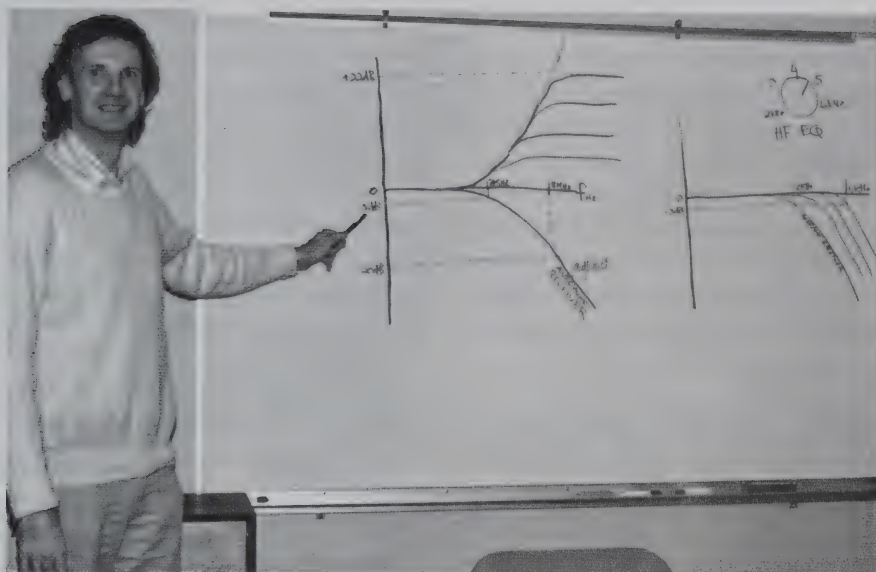


Fig. 25. Bob Orban explains his receiver equalizer in the new Optimod 9100A at the 1982 NAB convention. The Optimod-HF 9105A used the same circuit to correct for narrow receivers, such as the Sony ICF2010. (Photo courtesy of Bob Orban)

speech remained intelligible even under conditions that Ma Bell wouldn't have endorsed. I spent most of my 9105 'tuning' time listening to the radios in narrow mode. I didn't think at all about communications receivers, because the big international HF broadcasters were targeting consumers far more than they were targeting hobbyists: the middle "B" in "BBC" stands for "broadcasting," after all!"⁶⁴

Speech Processing

At a time when SSB RF speech processing developments were popular in the ham radio hobby, Mr. Orban developed a form of speech processing for his Optimod TV processor, and included it in the Optimod-HF. The novel addition was called a *Hilbert Clipper*, which

performed the clipping action of an RF speech processor:

"I also came up with the idea of the Hilbert Transform clipper at about that time, based on finding out about RF speech clippers and reading an article by Michael Gerzon,⁶⁵ which explained how to model an RF clipper entirely in the audio frequency domain without actual RF modulation and demodulation."⁶⁶

The Optimod-HF Hilbert clipper allowed RF-style clipping to occur in the lower audio frequencies and standard diode clipping for the highs, with an automatic threshold control to reduce bass distortion so that music could sound better. Bob added his patented

distortion cancelation around the clipper that allowed the processor to sound less distorted while clipping audio harder:

“The 9105 remains the most purpose-built of the Orban processors used for HF service because the 9105 had the Hilbert-Transform Clipper, which computed the envelope of the complex signal derived from the outputs of a 90 degree phase difference network, and which, after distortion cancelation, still corresponded roughly to the modulation envelope of an SSB transmitter.”⁶⁷

Distortion and Channel Limitations

As in the 9100A, the Optimod-HF had diode clipping with distortion cancelation around each of the 5-multiband audio limiters, which helped control overshoot and added to loudness. The Hilbert clipper, while adding loudness, also added distortion, and all of the combined clipping distortion added noise outside the intended radio channel. So in the 9105A, a very steep overshoot-compensated low-pass filter was used to protect the adjacent radio channel. With the availability of new software filter design programs such as FILSYN, low-pass filters using a newly developed frequency dependent negative resistor (FDNR or gyrator) became possible. These filters allowed for a very sharp cut-off, up to 36 dB per octave, but without the usual large inductors. The FDNR allows a resistor and capacitor tied around an op-amp to act as an inductor, mimicking an LC elliptical filter. Most broadcast processors incorporated

the new FDNR filters in the 1980s and 1990s, as they allowed for less adjacent channel interference than simple L/C filters as used in the UREI 1A and Langevin 1-C.

Sales Efforts Begin

After development, Bob Orban had prototypes built and offered them to the VOA and other shortwave broadcasters for testing and potential sale. Orban learned that some BBC Marconi transmitters would fail if 25Hz or 30Hz audio was passed to the transmitter, so he added notch filters in the 9105A to eliminate those frequencies.

Bob Orban visited Deutsche Welle in Germany, and after some initial resistance (the Germans were more measurement conscious than subjective), the broadcaster eventually bought Optimod-HF 9105As after reading Orban's paper describing the processor in the *Journal of the Audio Engineering Society*.⁶⁸

Back in America, Bob visited many U.S. broadcasters, and he recalls the large VOA transmitter site in Delano, California (whose many components are now owned by the AWA and displayed at their museum in Bloomfield, NY):

“I visited the VOA facility in Delano, and remember being impressed by the huge old plate-modulated transmitters (probably GEs, complete with walk-in transformer vaults) that they still had available for standby, although I believe they were using more modern transmitters for their main service by then. I was particularly impressed that they had already discovered and

implemented low frequency tilt equalization to maximize modulation capability, which Ron Jones of CRL didn't introduce to domestic MW AM processing until around 1978.”⁶⁹

The many techniques that made up the 9105A resulted in received audio that was the loudest to date and intelligible under the most adverse reception conditions, as Bob made sure speech was intelligible down to the noise level by testing with weak signals along with high noise and interference.

High Adoption Rate

While other HF stations continued to use simpler limiters on shortwave, many HF stations adopted the 9105A despite its high cost because it was the loudest processor available (the sales flyer stated that the Optimod-HF was 6–8 dB louder than a mono-band limiter) and was effective at cutting through interference. The Optimod-HF became the most popular processor for shortwave, and many are still on the air.

CRL MBL-100 AM Modulation and Bandwidth Limiter

Circuit Research Labs (CRL) built the MBL-100 AM Modulation and Bandwidth Limiter primarily for Radio Free Europe/Radio Liberty, and it was sold as a less expensive option than the 9105A. The MBL-100 shown in Fig. 26 was designed around 1990 by Gary Clarkson and Greg

Buchwald and used equalization, limiting, and filtering adapted for HF, but the MBL-100 had a simpler three-band limiting structure.⁷⁰

Description

Designed specifically to cut through noise and interference on shortwave, the MBL-100 had many of the same functions that the Optimod-HF, but in a simplified form. The controls on the MBL-100 consisted of an operate/bypass switch, input level, equalization, limiter drive, EQ and density, modulation level, and transmitter correction. In use, the equalization, drive, and density controls have the most effect. The unit was only one rack unit high. Inside, the MBL-100 had input filtering, an input asymmetry removal, AGC with gating, bass and high-frequency equalization (to improve intelligibility), a three-band limiter, a wide-band limiter, a steep low pass filter, and transmitter correction.

How It Started

Retired CRL engineer Greg Buchwald K9QI explained the beginnings of the MBL-100:

“The MBL-100 was a fun project that started when I met George Woodard

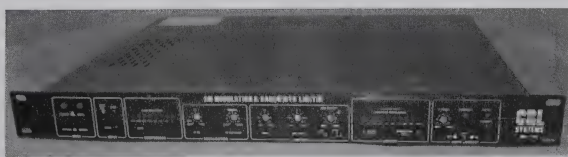


Fig. 26. The Circuit Research Labs MBL-100 AM Modulation and Bandwidth Limiter competed with the Optimod-HF at a lower price; about 70 were sold before being re-labeled as the Amigo-HF. (Author's collection)

(formerly of Continental Electronics, then with VOA) at an NAB convention in 1985. He asked me if any of my work I was doing on NRSC (pre-emphasis and RF emission mask) was useful to them—particularly for Radio Free Europe and Radio Liberty. I told him it had limited application but that I was looking at HF architectures for HF processing with CRL for Radio Australia . . .”

Sales

The processor was designed to optimize voice only, and CRL sold 25 units to RFE/RL. An MBL-100 was tested at an early stage at the BBC’s Daventry transmitter site 70 miles northwest of London. The power meters there showed a large increase in audio power over their previous processor; so much so that the

BBC engineers were concerned about transmitter failure due to the increased audio. Greg told me what happened when they installed an MBL-100 on a 1.6 megawatt transmitter in Saudi Arabia: “When they ran the first of those rigs up in the factory, the rebar in the floor underneath the output network cabinet got so hot from induced current that the cement exploded!”

Greg confirmed that the 9105A was slightly better than the MBL-100, but with a half to 1 dB tradeoff in loudness. After selling about 70 units, the MBL-100 was later renamed the Amigo HF and listed for \$3,995 in 2005 (equivalent to \$5,045 today). A variant was sold for domestic AM talk radio as Amigo Talk. Greg later worked on the C-QUAM AM stereo system at Motorola and is now retired.⁷¹

PART 4. ENTER DIGITAL SIGNAL PROCESSING (DSP)

Digital Signal Processing (DSP) allows analog signals to be manipulated in the digital realm. Real-time DSP systems most often use an input analog-to-digital converter, a very fast microprocessor with RAM memory, a control system, and an output digital-to-analog converter. PC-based computer programs can also process signals in real-time or modify stored files.

DSP allows for easy delay, nearly perfect filtering, the ability to have a new form of filtering called Finite Impulse Response, and a form of signal analysis using a Fast Fourier Transform. The tradeoff of using DSP is that processing

requires time, although often very little (usually milliseconds).⁷²

Digital signal processing necessitated a change in electronics prototyping and product development. Instead of breadboarding analog circuits and testing them, computer code, often written in C, C++ or assembly language, is required. Coding is often done on Windows PC computers using custom software development programs. And when ready to test, the code is compiled, then either initially run on a manufacturer’s development board or simulated in software on the PC. When the software is fully

working, the manufacturer designs a board around the DSP chip and support components to make hardware.

The VOA wanted to take advantage of DSP, and they soon did. They tiptoed into the digital world with the VISTA project, while commercial processor manufacturers rushed to adopt the new technology. The VOA eventually adopted the Orban Optimod 9200 and 9300, which they still use today.

Lincoln Labs Vista Project

The “Voice Intensification using the Sinusoidal Transformation Algorithm” (VISTA) system for AM broadcast was an experimental project by MIT’s Lincoln Labs as a novel way of achieving enhanced intelligibility by reducing the peak-to-rms ratio of speech. In a final technical report published in 1990, Tom Quatieri and his speech technology team described how they developed digital algorithms to increase transmitted audio power for the VOA.⁷³

Radar and Speech Synthesis

The unique features of this system were the techniques to reduce voice peaks, which included speech synthesis and adaptive phase dispersion taken from RADAR signal processing. Amplitude, phase and spectral information were detected using a Fourier transform at the input and a new voice signal was dynamically synthesized to create a symmetrical signal. Then, the usual automatic gain control and audio compression were also added, as were spectral shaping and clipping techniques that were used in previous processors.

Controls

Enhancement mode settings for mild, normal, and extreme processing were provided, as well as three modes of pre-emphasis: none, medium (for a normal shortwave radio), and heavy (for a narrow radio). Two presets could be stored for quick recall and the control terminal could show the peak to rms ratio for different lengths of time.

Real-Time

Sponsored by the VOA between 1986 and 1989, the MIT team first proved the concept on a non-real-time simulator that processed stored audio. Once the concept was proved, they then developed a real-time system using a card cage that held seven early DSP boards that processed live audio. A control card interfaced between the DSP cards and allowed control by a separate computer and terminal where processing parameters could be set and resulting audio measurements made (Fig. 27). Near the end of the project a stand-alone system was delivered to the VOA for testing.

Testing

First, the developers and others at Lincoln Labs evaluated their efforts as they refined the system. Speech verification tests were later performed at Indiana University where 12 subjects listening to three systems at three signal-to-noise ratios judged the effectiveness of each system and setting.

Early automated bench testing consisted of a test signal generator where noise could be added (a now common test method). A UREI 1A, a CRL processor,

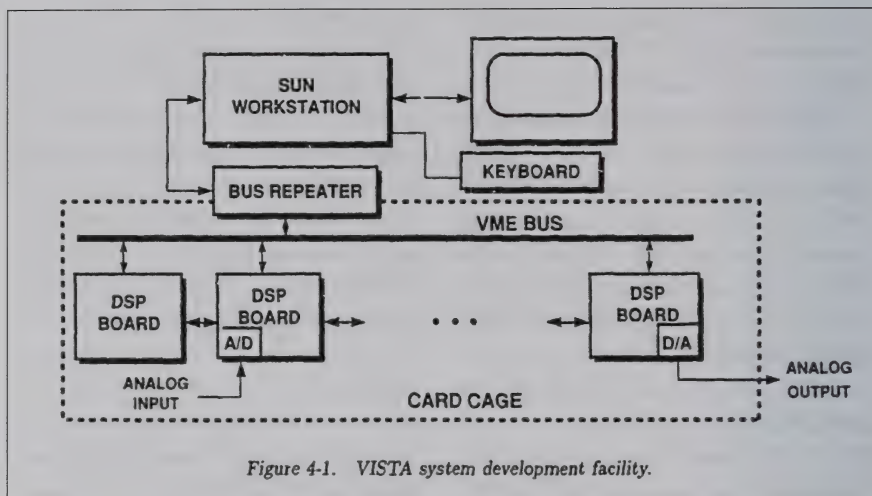


Figure 4-1. VISTA system development facility.

Fig. 27. The VISTA block diagram showing DSP boards controlled by a computer. This was a research project at MIT's Lincoln Labs to determine if speech synthesis and clipping could be louder than traditional processing. (VISTA Report, <http://www.dtic.mil/dtic/tr/fulltext/u2/a219665.pdf>)

a homemade standard diode clipper, and an Orban 9105A were used for comparison to the VISTA system. Standardized voice tapes along with VOA programming were used to evaluate intelligibility. Histograms of the signals were made, and peak/rms values were calculated. In the end, the VISTA system was mostly compared to the Orban 9105A, which was brand new and state-of-the-art at the time (and eventually adopted by the VOA).

Was VISTA Better?

The Vista system was about 3dB louder than the Optimod-HF in the lab. However, in 1988 the real-time VISTA system was tested at the VOA Greenville transmitter site and compared with a UREI 1A and a prototype Orban 9105A. A Kenwood R2000 communications receiver was used in Boston to record and

judge the tests, which were compared to measurements made at Greenville.

As stated in the VISTA report: "The VISTA and commercial (Normal) were at about the same quality and loudness levels. The commercial (Severe) was slightly louder, but noticeably poorer in quality. The VOA system was not quite as loud, and was comparable in quality."⁷⁴ This early shortwave DSP effort provided about the same loudness as the 9105A on-air, but had about a 3 dB improvement in the lab. Plans to improve the software may not have been executed as the project apparently ended after 1990. Newer digital commercial processors soon exceeded the loudness capability of the Optimod-HF 9105A and the VISTA system.

Having authored a book on discrete time speech signal processing and many papers on speech processing and

related fields, Tom Quatieri specializes in human language technology as a senior member of the technical staff of Lincoln Labs, and is a leader in this field.

The Orban Optimod 9200 HF and 9300 Processors

With Bob Orban's digital designs, most of his previous analog processor functions were simply reproduced digitally, but new digital techniques were soon added. In these new units, Bob was able to provide a louder and cleaner signal than what was possible using analog techniques. Clipping distortion was reduced much further than could have been achieved in analog processors, and his processors were eventually reduced to a single rack unit in height. For domestic AM and HF, Orban first came out with the Optimod 9200 DSP processor of Fig. 28 in 1997, which was discontinued after the improved 9300 processor shown in Fig. 29 was introduced in 2007. The 9300 processor is still on the market today. In the new units, anti-aliased clipping was added, reducing distortion even further. Bob adds:

“The main technical problem solved by the DSP-based processors was the unavailability of truly linear-phase filters in the 9105A, which limited the

effectiveness of the overshoot compensation compared to what could be done in by FIR filters in DSP.”⁷⁵

Optimod 9200

Reduced to two rack units, the Optimod 9200 was the first all-digital DSP processor for AM and HF, and was adopted in many VOA sites. The 9200 operating manual boasted the unit “. . . has cleanliness, quality, and stability over time and temperature that is unmatched by analog processors.”⁷⁶ The processor now had eight factory presets that could be customized and saved. The unit also had an adjustable low pass filter from 4.5 kHz to 9.5 kHz, as compared to the older 9105A's fixed 4.5kHz filter. Downward expansion was added to the multiband limiters to further reduce noise,



Fig. 28. The Orban 9200 was the first DSP processor used for shortwave. The 9200 was used in domestic AM stations, and many shortwave stations adopted the HF version called the Optimod 9200-HF. (<http://www.w9ad.com/images/hamshack/orban.jpg>)

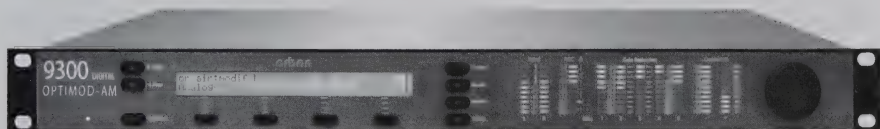


Fig. 29. After buying the Optimod-HF 9200s, the VOA selected the newer Optimod 9300s when the improved model was introduced. Many HF stations adopted this smaller unit, which improved loudness and quality. (<https://www.orban.com/optimodam-9300>)

and many more user adjustments were made available.

Optimod 9300

The revised and even smaller Optimod 9300 added improvements to the 9200 such as an oversampled digital clipper derived from Orban's FM processors, which reduced aliasing distortion, thus allowing for an even cleaner signal. The 9300 is now one rack unit in height and sounds smoother.⁷⁷ Bob Orban adds:

"If I recall correctly, in addition to anti-aliasing the clippers, the other big processing improvement between the 9200 and 9300 was the introduction of the parametric lowpass filters that allowed the shape of the filter's transition region to be changed to trade off filter ringing against flat frequency response right up to the cutoff frequency."⁷⁸

Digital Quickly Adopted

The Optimods 9200 and 9300 became widely used in the domestic AM broadcast market, and many were used in HF. It was no longer necessary to make a processor specifically for shortwave because DSP allowed for more user adjustments to match their needs. The new digital Optimods had an HF preset that emphasized the midrange and had a user-adjustable lowpass filter that could be set to 4.5 kHz for shortwave broadcast, but Hilbert clipping was abandoned. Bob Orban notes:

"The main advantage of the 9105A over the general-purpose DSP-based MW

processors was its Hilbert-Transform clipper, which was not used in the DSP units because it is not as well-suited for music as the clipping systems used in the DSP-based processors."⁷⁹

The VOA adopted the Optimod 9200-HF version in many of their sites early on, and later they adopted the improved 9300—thus replacing all the aging 9105As. Audio reception was louder and distortion free, which you can hear if you tune to a VOA frequency or to many domestic AM stations today.

No More HF Designs

As shortwave waned, Bob Orban decided to forego designing a digital processor specifically for HF:

"In the mid 1990s I didn't think that it was worthwhile to make a dedicated DSP processor for HF because the major HF broadcasters already had bought 9105s and the clear trend was for these services to be shut down. HF broadcasting was not a growth industry by then. However, I am looking (slowly) into creating processing for ham radio, which will require very good support of SSB peak control."⁸⁰

The Optimod 9200 HF listed for \$4,350 in 2005 (equivalent to \$5,494 today), while the 9300 lists for \$4,950 today—with higher performance than the 9105A—and at a lower price. During his career of developing processors, Bob Orban obtained patents for ideas such as a multiband processor, bass clipper, distortion-cancelling clipping, receiver

EQ, Hilbert clipper and a high-frequency limiter. For his later DSP efforts, Orban also obtained patents for an oversampled differential clipper and a half-cosine peak limiter. Bob Orban has been a leader in processing for decades, and is the founder and chief engineer of Orban Labs, Inc.

Epilogue

Operating Efficiency Becomes Important

The VOA decided to reduce the number of transmitters as jamming from the Soviet Union ended in May of 1987.⁸¹ In 1994 the VOA was reorganized under the International Broadcasting Bureau, a new structure created by President Clinton when he signed the International Broadcasting Act into law on April 30. By 2002 optimum HF coverage had been achieved and priorities changed. Cuts in VOA services began in 2008, and languages such as Russian and Greek were halted as Voice of Russia broadcasts were curtailed.

The competitive nature of shortwave relaxed while at the same time fuel costs increased. Financial analysts at shortwave outlets demanded lower power bills, and so transmitter output power was reduced. Transmitters with 500 kW ratings were often run at 250 kW, while 250 kW transmitters were run at 100 kW. Shortwave broadcast audio processing helped in retaining a viable audience with these lower powered signals.

To further reduce their large electric bill, the VOA (and other broadcasters) tested something called carrier control, which was given the name “Advanced Modulation Companding” (AMC). Companding is a combination of the

words “compressing” and “expanding,” and AMC reduced the carrier level as the modulation increased, saving carrier power. All transmitters with carrier control used transmitters with high-efficiency solid-state switching modulators that enabled this option. By 2011, the Broadcasting Board of Governors converted most of their shortwave transmitters to AMC and claimed a power savings of \$1.5 million.⁸²

Shortwave Becomes Less Important

The heyday of super-power shortwave was in the 1990s, when the Voice of America transmitted some 2,611 hours per week to a worldwide audience.⁸³ SSB broadcasting had been discussed as a future mode of broadcasting, but was never adopted. In the 1990s, a few stations tested a digital method of delivery called *Digital Radio Mondiale*, but it too was not adopted.⁸⁴ Since the late 1990s, shortwave has become less important as reliable media distribution became available on the Internet—and with no fading or interference. Consumers now had the convenience of obtaining news and information interference-free by using their computers and smartphones. Broadcaster, teacher, and shortwave listener Robert Dunn noted that government funding for shortwave often dried up:

“Funding has often been problematic for international broadcasting stations, if for no other reason than their listeners were in other countries. With an “out of sight, out of mind” constituency, convincing legislators to fund

broadcast stations has often proved challenging. With the rapid development of private access to the Internet and the refinement of digital audio streaming techniques, stations began to exploit these seemingly less costly means of program delivery.”⁸⁵

Most shortwave outlets left the air entirely and used the Internet to reach their listeners; however the VOA still broadcasts to limited audiences on shortwave as well as Internet and FM services. They even send a weekly digital *VOA Radiogram* over HF that delivers news articles and images using MFSK32 coding and other modes.⁸⁶

Today there is continued audio research for improved broadcast audio processing, but this work is now aimed primarily at domestic FM broadcasting. Some of these advances could be applied to shortwave broadcasting if there was a market, but little money would be made today in creating a dedicated processor for the shortwave industry.

Summary

As the VOA increased coverage by adding higher-powered transmitters and relay sites, higher-gain antennas and optimized signal path usage by propagation software, the VOA took advantage of advancing audio techniques to maximize program delivery on shortwave. The evolution of audio processing with the Langevin 1-C, Kahn Symmetra-Peak, Gates Level-Devil, UREI 1A, Orban's Optimod 9105A, 9200 and 9300 helped combat jamming, increase coverage and intelligibility, and finally reduce energy

costs. As the science and art matured, commercial broadcast processing was adopted and DSP won in the end.

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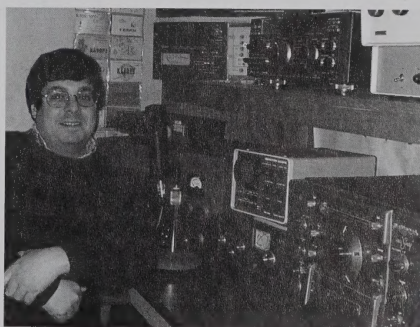
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About The Author

Born and raised in New Orleans, **Daniel Brown** started listening to the Voice of America and other shortwave stations in the late 1960s. Dan currently works as a broadcast engineer at the WGBH Educational Foundation in Boston where he supports the broadcast studio, file-based media, automation, and transmission equipment. Mr. Brown has consulted, installed, and adjusted audio processing for broadcast stations. Dan is a member of the Society of Broadcast Engineers (CBNT, CBTE) and the Audio Engineering Society.

An Extra Class amateur radio operator (W1DAN), Mr. Brown is the Eastern Massachusetts ARRL Technical Coordinator, the president of the Wellesley Amateur Radio Society, and an ARRL life member. Dan is also an AWA life member and has written numerous articles about radio in various national radio publications. Mr. Brown resides in Natick, MA, and can be reached at danbrown1dan@gmail.com.



Dan Brown

Letter to the Editor

Re: The Cradle of College Radio: WJD and the Prescient Professors
by Mike Adams, Vol. 30, 2017

Dear Mike Adams:

I read with great interest your *AWA Review* article on Dick Howe and early radio at Denison University. My father, Charles Brelsford, entered Denison in the fall of 1925, majoring in physics. He already knew Dick through radio, and they became lifelong friends. In his memoirs he mentions broadcasting football games that fall; your article explains why he didn't mention doing it in later years.

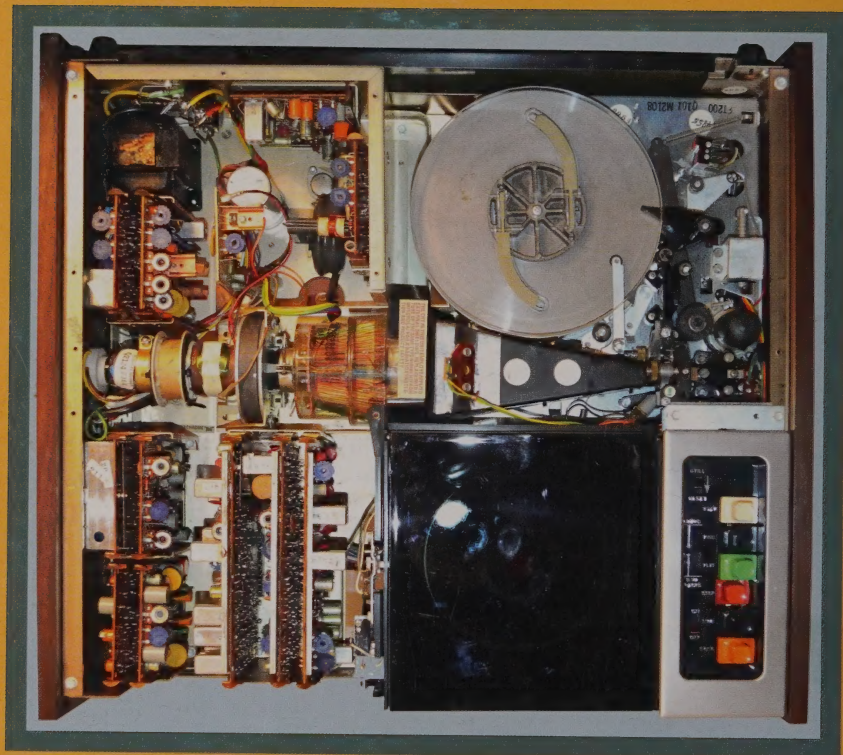
I remember Dick well from visits during our family trips to Ohio and from occasional radio contacts. His callsign was W8CBN then; later (mid-60s?) he was issued W8YM (which he could get because he previously held 8YM).

Dad was W2CTA, later K2WW, and, as you may know, he was the second president of the AWA (1972–82). His brother, Ernest K6TZ, was four years ahead of him at Denison, and also a student and friend of Dick's. Their father (my grandfather) was pastor of the Baptist Church in Granville and served as treasurer of Denison. Dad and Ernie got in trouble one day for stringing an antenna from their house to the top of the church steeple.

At some point Dad acquired the Grebe CR-6 and CR-7 receivers you mentioned. He passed them on to me; I sold them to other AWA members before we moved West from New Jersey (at somewhat higher prices than the original purchase!).

Thanks for researching and publishing the article, which I thoroughly enjoyed reading.

—**Bill Brelsford**, K2DI, Yachats, OR



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